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SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 61

VARIATIONS AND GENETIC RELATIONSHIPS OF THE GARTER-SNAKES

BY

ALEXANDER G. RUTHVEN

Curator of the University Museum, University of Michigan, Ann Arbor

WASHINGTON
GOVERNMENT PRINTING OFFICE
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Richard Rathbun,
Assistant Secretary, Smithsonian Institution,
in charge of the United States National Museum.

Washington, U. S. A., *June 15, 1908.*

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THAMNOPHIS ORDINOIDES ELEGANS (TULE LAKE, OREGON).

VARIATIONS AND GENETIC RELATIONSHIPS OF THE GARTER-SNAKES.

By Alexander G. Ruthven,

Curator of the University Museum, University of Michigan, Ann Arbor.

INTRODUCTION.

In these times, when there is so great activity in evolutionary research along all lines of biological work, it is important that systematic studies be directed so as to throw light on the problems involved in the origin of species. An examination of the actual sytematic work that has been done, however, can not fail to reveal the fact that only a comparatively small amount of it has been done with this end in view. This is especially true in the case of reptiles, and more particularly in the order Serpentes, where but little work has been contributed to this phase of the subject. Without doubt one reason for this is to be found in the fact that the snakes are a most perplexing group systematically, owing to the difficulty in finding characters that are capable of defining natural groups. For this reason but a comparatively small amount of work has been done on the group. As Baird said in 1853 (1853, p. v.), "Systematic workers all carefully avoid the subject of Ophidians, each waiting for the others to make the first step;" and although in the fifty years that have elapsed since this statement was made considerable work has been done upon the order, and a multitude of forms have been described as the result of the careful studies of Baird, Stejneger, Cope, Garman, Brown, Van Denburgh, and others, only a very few conclusions have been reached as to the origin and descent of the forms.

This barrenness of general results can not be entirely attributed to a lack of facts, but must be inherent, to some degree at least, in the methods employed. An examination of the systematic work that has been done upon the snakes shows, as might be expected, that it is largely analytical in its nature, being for the most part descriptive of the existing diversities. That this kind of work is of value can not be questioned, for, as has been well said by Tutt (1896, p. 6): "The species describer, if he does his work intelligently and carefully, is giving the evolutionist the exact material on which alone

any stable conclusions can be drawn with precision, and, if his work is thus valuable, we must still recognize, nay, welcome, those who give their best powers to the unraveling of the species in their multitudinous forms, since these form the basis of all advanced evolutionary study." While the value of the analytical method must, therefore, be admitted, its limitations should be clearly seen. Needless to say it is not a knowledge of the present conditions alone that is necessary, which is all that the application of this method can yield, but a knowledge of the processes that have brought them about, for systematic work can only become a true science when it seeks to formulate the laws involved in the history of the present forms.

The history of a particular form can not be worked out by determining its characters alone, but its affinities must be sought for, by determining its similarities with other forms, and the factors which influence it, before its derivation can be discovered. After analysis, therefore, as has been said, comes the need of a larger synthesis. This argument is often verbally granted by systematists, who, however, still adhere to the analytical method with the plea that a sufficient body of facts has not as yet been accumulated upon which to base general conclusions. This may probably be said of snakes with more truth than for many other groups, but, when it is noted that the work that has been done offers very little material upon which to base such general conclusions, it would seem that a few generalizations based upon such limited material as is now available might in many cases go far toward directing the course of future analytical work toward better results. In the words of Meldola (1896, p. 7), "However large the number of facts, and however cautious or conservative the worker may be, it is an established doctrine, taught by the whole history of science, that real progress begins when we go to seek for facts armed with at least the suggestion of a principle if not with a complete theory based on facts already accumulated by observation or experiment."

Furthermore, it seems to be evident that any comprehensive attempt to do synthetical systematic work must be made upon a geographic basis, for the interrelations between the organisms and their environments are such that the history of the present forms is involved with the history of the conditions with which they are associated, and affinities can only be sought in the light of geographic probability. As Adams (1902a, 356) puts it, "It should be apparent that in the past history of a region the conditions and highways must be taken into consideration if we wish to understand the origin and migrations of the diverse elements which enter into the fauna and flora of any given region." As a study of the interrelations between organisms and the natural environment, geographic distribution

attains to a wider significance than it has previously enjoyed. Hitherto, as the result of the application of analytical methods to taxonomy, it has been largely static in its nature, as it concerned itself principally with the determination of the present distribution of the forms as if this arrangement were fixed, thus affording only a description of the present conditions. In connection with the synthetic method, however, it is more comprehensive and essentially dynamic in its nature, for it not only takes note of the present distribution of the forms but at the same time recognizes the close relations that exist between this arrangement and the environment, and its consequent unstability, and by the determination of the laws of change furnishes a powerful aid to the interpretation of the past history of the present forms, without a knowledge of which it is impossible to explain the present conditions.

THE TAXONOMY OF THE GARTER-SNAKES.

PRESENT STATUS OF THE GENUS.

As an example of the confusion into which a group may be thrown by systematists who see in every association of traits a species, probably no better could be found than that of the common garter-snakes of North and Middle America, composing the genus *Thamnophis* Fitzinger. This genus has long stood in the minds of herpetologists as a synonym for chaos, and has been a source of trouble to those who attempted to compile local lists, for specimens may be found in almost any locality which can not be referred exactly to any described form, or doubtfully to two or three. The result has been that in the attempt to express these differences the method of analysis has been carried to the extreme, and something like sixty-five forms have been described.

This has not solved the problem, however, for, owing to the extent of variation and the fact that descriptions have been based on different combinations of traits without an adequate knowledge of the variations, it has been practically impossible to define accurately any of these forms. In nearly every species the characters often seemingly grade off in different directions independently of one another, and it has happened more than once that a diagnosis has been subsequently shifted from the form represented by the type-specimen to an entirely different one, by the author of the species himself. Anything approaching a natural key was not to be thought of, and a worker was fortunate if he could devise an artificial one that would sufficiently define the forms in particular regions so that they could be recognized. It is an instance where the insufficiencies of the methods applied have been thrown prominently into the foreground by the nature of the material,

for a widely ranging and variable group with all the diversities brought about by environmental and racial influences does not furnish the most favorable material for the application of purely analytical methods.

An examination of the most comprehensive work that has been done on the garter-snakes will show this. In his "Crocodilians, Lizards, and Snakes of North America" (1900), Cope has described the diversities in an exhaustive way, recognizing in all forty-six forms. Diversity is all that this work reveals, however, and a more minute splitting of the forms would only increase the complexity. Here one is shown the actual living varieties as they exist in North America to-day; the present conditions with all of their anomalies and apparent contradictions, with no key to possible relationships.[a] What is needed, it seems to me, is not more analysis but a greater knowledge of the affinities of the forms, so that the continuity of genetic relationships underlying the present diversities can be grasped.

METHODS EMPLOYED.

Three steps are necessary to determine the genetic relationships and simplify Cope's elaborate arrangement of the group: (1) The value of the characters must be determined; (2) the geographic probabilities must be utilized; (3) similarities and intergradations must be sought.

It may seem superfluous to insist upon the determination of the value of the characters used in systematic work on this group, for "good" characters, i. e., those which are constant within particular groups, are sought after by most systematists in forming their taxonomic groups, but in the sense in which it is here used this rule means more than this, in that it also requires the discovery of the significance of the variations.

In the work that has been done, as has been said previously, whenever a more or less stable combination of traits has been observed it has been described as a distinct form, and this with utter disregard as to how the distinctive characters may have been derived. For instance, *elegans* is separated from *radix* by the position of the lateral stripe, from *parietalis* by the smaller number of dorsal scale rows; *sirtalis* is separated from *radix* by the position of the lateral stripe and by a difference of two rows of dorsal scales, from *butleri* apparently only by the width of the lateral stripe. In these cases it has been sufficient to ascertain that these characters are little variable within the form, but what relations can be worked out from such facts until

[a] It is true that twenty-seven of the described forms are considered subspecies, and a diagram of affinities has been worked out, but the latter is mostly hypothetical, while most of the subspecies are either based merely upon individual variation or are erroneously arranged.

it is ascertained to what extent these characters are subject to modifications? Only when this is known can we hope to accomplish much in our attempt to discover the origin of the present forms.

This is very well illustrated in the synthetic taxonomic work that has been attempted. Several efforts have been made to combine the described forms into natural groups, and Stejneger, Brown, and Van Denburgh [a] have, in various papers, endeavored to establish the proper status of the different forms. The most comprehensive essay is that of Brown (1901) in his "Review of the Genera and Species of American Snakes North of Mexico," which appeared in 1901, and which may be considered as a reaction from the extreme position taken by Cope (1892) in his paper "A Critical Review of the Characters and Variations of the Snakes of North America." In this work Brown has attempted to unite the different forms into related groups, and, as will be shown later, has succeeded very well in some instances. But commendable as are his efforts, the methods employed, it seems to me, are unfortunate. For example, *sirtalis*, *leptocephalus* (*ordinoides*), *butleri*, *parietalis*, and *pickeringi* (*concinnus*) are united in one group on the basis of similarity in the scutellation without regard as to whether or not the characters included under this head are influenced by *definite variation*, and until this is determined there may be another explanation for similarity in scutellation than community of origin, namely, *parallel development*.

That there is convergence among the garter-snakes is illustrated by the fact that so high an authority as Boulenger (1893, 418) gave it as his opinion that the type of *brachystoma* (*butleri*) was a specimen of *leptocephalus* (*ordinoides*), incorrectly labeled as to locality. As Cope subsequently showed, there is no doubt as to the correctness of the locality, so that it is highly improbable that the two forms are directly related, and yet the parallelism is so close that if unlabeled as to locality it is often very difficult to distinguish between specimens of the two forms. (See also p. 188.) It is essential, therefore, to determine first of all along what lines the present combinations of characters may have developed, in order that there may be no confusion by parallelism.

Another prime objection to the synthetic work that has been attempted is that the *geographic probabilities* have been so largely disregarded. A knowledge of the extent of the variation in any form affords little evidence of affinities if the geographic trends are ignored

[a] Garman's arrangement (1883) is in many respects the most comprehensive, as he considers the group in detail. There is, however, so little basis given for the grouping which he has adopted, and so many manifest errors, that his synopsis must be considered rather as an effort to reduce the number of species than as a rational attempt to establish natural affinities.

as they always have been in this genus. And again while the law that the direct relative of any form will generally be found in a neighboring environment (see p. 192) may not be universal among the vertebrates the evidence at the present time shows that it is valid in a great number of cases, so that one must be very cautious of this point in grouping the forms of any group.

Cope in his general work recognized five varieties of *sirtalis* east of the Mississippi River, and yet the range of these forms could not be defined relative to each other, as they were reported from various parts of the same region and in association with numerous other varieties of the same stock, in utter defiance of the above law, but as most of these forms were based on slight variations and have been mostly dropped, they do not merit detailed discussion. The affinities that have been claimed for recognizedly distinct forms, however, is open to the same criticism. For example, if *ordinoides* and *concinnus* are both derived from *parietalis*, one must invoke the aid of some form of physiological isolation to account for their present distinctness, for they occupy the same region and environment, and *concinnus* is not considered far enough separated from the parent stock to be classed as a distinct species. Similarly also the derivation of *radix* from *sirtalis* is different from what one might expect from their geographic location, for *radix* lies entirely within the range of *sirtalis* and *parietalis*. Thus geographic probability must also be observed in tracing genetic lines if we would avoid the grouping of forms of diverse origin, which by their similarity might reasonably be adjudged to be related.

Having determined the significance of the variations, and by observing the geographic probabilities, considerable advance may be made toward determining genetic relationships, and it only remains to look for similarities and intergradations. For example, we may thus have determined that the smaller scutellation of *ordinoides* may have been derived by dwarfing from some other form with a larger number of scales, and that it is possible, geographically, that it may have been derived from the snakes of southern California or from those in the Great Basin. It is not enough to say that the present combination of traits which we call *ordinoides* is constant, but we must cast about for similarities with neighboring forms in order to determine its origin if we are to avoid the multitudinous varieties of systematists whose vision is blurred by the present divergences. The species-describer searches for pure types which are found only away from the geographical meeting places, but if we wish to discover relationships we must not avoid the boundary lines, but seek them. If we search for similarities in the light of the influence of modifying factors on the characters, and with an eye to geographic probabilities, we should be able to see back of the present diversities, grasp the natural affinities, and come in touch with the questions of origin and descent. It was

in the belief that the application of these methods to the group of garter-snakes would lead to such results, and thus greatly simplify our present knowledge, that this work was undertaken.

MATERIAL EXAMINED.

The conclusions reached in this paper are based upon a detailed examination of about three thousand specimens gathered from nearly every part of the known range of the genus,[a] so that I believe my knowledge of the variations is well founded so far as it goes. It must be acknowledged, however, that much remains to be done, for, owing to the fact that it has been found impossible to obtain extensive series from many localities, that entire forms are at present known from but few specimens, while in the case of some well-known forms specimens are unavailable from critical localities, it is impossible, in some instances, to do more at present than point out the probable relations, leaving them to be substantiated by detailed work when specimens shall be available.

One objection to the material that has been used is that it has been largely alcoholic, and it must be admitted that, as some of it has been in preservation for fifty years, it has not always been all that could be desired. This has been more of a limitation to the work, however, than a source of error, for the principal characters employed in the systematic work (scutellation, position of stripes, and tail length) can not become greatly modified in this way, and, although the color may become very much faded, the color pattern may in most cases still be made out.

A far more important objection to the material is that many of the specimens have but general locality labels, and throughout the present work it has been continually impressed upon the writer that *too much attention can not be paid by collectors to the securing of detailed locality and habitat data*. Specimens that are not labeled accurately, at least as to locality, are almost valueless in this work, while if habitat data were only available in each case much light would be thrown upon the explanation of the present distribution.

ACKNOWLEDGMENTS.

In the prosecution of the research upon which this paper is based I have become indebted to a number of persons without whose aid little could have been accomplished.

I wish first of all to acknowledge my indebtedness to Mr. Charles C. Adams, under whose direction the work has been carried on, for his

[a] The specimens examined represent every described form, with the exception of the *Eutaenia praeocularis* Bocourt (Le Natur, 1892, p. 278), from Belize, British Honduras. I am not certain of the identity of this form.

continued interest in its progress, and for many helpful suggestions and criticisms, particularly upon the general method of approach.

I am also greatly indebted to Dr. Leonhard Stejneger for the privilege of studying the material in the United States National Museum; to Mr. A. E. Brown for the opportunity of examining the specimens in the Academy of Natural Sciences of Philadelphia, and to Messrs. Whitmer Stone and James A. G. Rehn for assistance in doing so.

I am particularly indebted to the Field Museum of Natural History in Chicago, through Dr. S. E. Meek, for the loan of their excellent series of specimens, which has furnished the solution for several knotty problems that otherwise must have remained obscure. For the loan of the material in the American Museum of Natural History I am indebted to the Director, Dr. H. C. Bumpus.

My thanks are also due to Dr. Raymond Pearl, Agricultural Experiment Station, Orono, Maine, who suggested the method employed in plotting the variations in scutellation in the different forms. Most students of systematic zoology avoid statistical methods, which is unfortunate, as a graphic description is always much clearer than a written one. Simple diagrams, similar to the ones used in this paper, are easy to prepare, and summarize in the clearest and most concise manner the geographic variations in a form, and should be employed whenever possible. It may be well to say here that in these diagrams × denotes the arithmetical mean, the heavy lines the range of variations, O the mid-point of the range (the average of the two extreme individuals), and the numerals in the diagram the number of specimens; also that the stars on the maps do not represent the exact locality from which specimens have been examined.

I am also under obligations to many persons for aid in securing living specimens from localities from which records were desirable.

GENUS THAMNOPHIS.

DESCRIPTION.

Scutellation.—The genus *Thamnophis* of Fitzinger (1843, 26), established upon the *Coluber saurita* of Linnæus (1766, 385), and later defined as *Eutaenia* by Baird and Girard (1853, 24), belongs to the family *Natricidae*, and differs from its nearest American relative, *Natrix*, by the absence of scale pits and the presence of an undivided anal plate.

The cephalic plates are normal, consisting of paired internasals, prefrontals, occipitals, and parietals, and a single frontal. A loreal plate is present; the rostral normal in form and the nasals divided, the nostril being between them. There is usually a single preocular on either side, but in three forms (*elegans*, *ordinoides*, and *hammondi*)

there are frequently two, in two others (*angustirostris* and *melanogaster*) mostly two, and in one (*angustirostris*) frequently three.

The postoculars are most often three in number, occasionally varying individually to two or four, in one form (*melanogaster*) being very frequently two. The temporal plates are ordinarily one followed by two or three, but in one form (*butleri*) there is frequently but a single plate in the second row; occasionally the first temporal is divided, and frequently there are four scales in the second row, but these are individual variations. The supralabials are 6, 7, 8, or 9 on either side, the eye resting upon the third and fourth, or fourth and fifth, except in *angustirostris* in which the lower postocular is prolonged forward beneath the eye to separate the orbit from all but one supralabial.

There is a triangular mental plate at the symphysis of the lower jaw, and posteriorly from this the infralabial plates, 8, 9, 10, or 11 (very rarely 12) in number, extend to the posterior angle of the mouth, being separated, except the first pair, which are prolonged inwardly to meet on a median line, by two pair of chin shields. The anterior pair of chin shields is usually the shorter, but in two forms (*ordinoides* and *elegans*) they are quite constantly equal or longer than the posterior pair.

The maxillary teeth are apparently as in the other forms in the family, i. e., rather abruptly longer near the posterior end of the maxillary bone than anteriorly. The genus *Atomarchus* Cope (*Stypocercus, Chilopoma*) was based on forms in which the maxillary teeth were equal throughout (*melanogaster* and *angustirostris*), but, as later stated by Cope, the excess in the length of the posterior teeth is so small in many specimens of other species that it is impossible to distinguish them from apparently isodont specimens of these forms, while we have, moreover, seen specimens of *melanogaster* in which the posterior teeth were nearly, if not quite, as elongated as in any form in the genus.

On the body there are 17 to 23 longitudinal rows of dorsal scales; these being normally arranged in an even number of rows on either side of a median dorsal series. The scales are all keeled with the exception of those of the first row, which are usually smooth or but weakly keeled; in one instance (*melanogaster*) those of the second row also tend to become smooth, the keels being generally weaker than those of the rows above.

The abdominal plates consist of a single series of large transverse scutes that vary in number both individually and racially, the extremes for the genus being about 132 to 180 from chin to anus. The anal plate is almost invariably entire, while the subcaudal plates, which like the abdominal plates are also variable in num-

ber, consist of a double series of scutes about 49 to 134 in number from the vent to the tip of the tail.

Color.—The color pattern may be described in general as three light stripes upon a darker ground, and, although there is considerable detail and variation in color, this description will be found to hold in a general way for the genus.

The ground color on the scales above the lateral stripe varies, as a rule, from dark yellow at one extreme through the olives to black at the other, and usually, when light enough to show it, exhibits longitudinal rows of black spots. Where best developed (*radix*) these spots are arranged in three longitudinal series on either side, one below the lateral stripe and two above, the individual spots of each series alternating with those of the adjacent rows. The arrangement is not always so regular, however, for from this ideal condition, so to speak, variations occur in various directions. In the greater number of instances the spots of the first row are broken up and do not form a definite series, while in many cases also the spots of the second and third rows are interrupted by the ground color along the keels of the scales. Frequently the spots of all three rows tend to fuse with those of adjacent rows and form transverse bars or blotches, and in one form (*scalaris*) this is the pattern throughout the length of the body. Occasionally the spots retreat from the scales, becoming reduced to narrow broken lines along the stripes, and in one group (*Sauritus*) this is the characteristic pattern. In other forms the scales between the spots are occasionally red. In all of the forms exhibiting one of these styles of coloration the spots may be entirely obscured by the darkening of the ground color, which in some forms seems to be the typical condition.

When the skin is stretched the scales are drawn apart, and it is seen that the lateral spots on the scales represent corresponding series on the skin. Those beneath the first row are difficult to observe, as the skin is here apparently less distensible; they are evidently, however, like their representatives on the first row of scales in that they are more subject to irregularities, and are seldom to be made out as a definite series. Above the lateral stripe the second and third rows are usually distinct on the skin, whether or not the spots on the scales are broken up or obscured by the ground color. They also show a tendency to fuse, however, and this fusion may either take place by the general fusion of the spots, leaving only scattered light patches to indicate the interspaces; by transverse fusion into bars; by the fusion of the upper row, which may involve also part or all of the second row, the interspaces being limited to the vicinity of the lateral stripe; or more rarely the two series fuse as two longitudinal bands.

When the spots on the skin are generally fused, those on the scales are either wanting or represented in narrow broken bands along the stripes, as mentioned above. When, however, the latter show a tendency to form cross-bars, the spots on the skin exhibit the same arrangement. Practically always, however, the first spot of the two rows above the lateral stripe fuses with its neighbor to form a large nuchal blotch, which may or may not be distinct on the scales. These blotches may cross the lateral stripe and fuse with the corresponding spot on the first row of scales, and in one section of the genus (the *Sirtalis* group) are frequently followed by one to five similar blotches which are likewise formed by the fusion of the spots of the second and third rows. The color of the skin in the interspaces is usually white or very light bluish or greenish, but it may also be yellowish or red, and the color of the interspaces usually encroaches to a varying degree upon the involved scales.

The stripes are typically three in number, consisting of a dorsal which involves the median and usually a varying amount of the adjacent rows, and a lateral on either side situated on the second and third, third, third and fourth, or second, third, and fourth rows from the belly. The color of these stripes is usually brighter than the ground color, being white, various shades of blue, green, or yellow, or occasionally red. The laterals, while frequently narrow, usually involve two rows of scales. In one form (*butleri*) they cover part of three rows, while in another (*marcianus*) they are, for most of the length, on one only. In only two forms (*angustirostris*, *sumichrasti*) are they characteristically obsolete. The dorsal stripe, on the other hand, varies in width from one to five or six rows and is more often lacking. Neither the dorsal or laterals are absent individually except in melanistic specimens, being very constant in the forms which possess them.

The head is usually of the same color above as the ground color of the back, but it is often more olive or brownish, and is occasionally marked with red or black. There are nearly always two proximate bright spots upon the parietal plates, although these are occasionally absent in individuals irrespective of race. On the sides of the head the dark color of the upper surface meets the usually much lighter color of the superior labials, into which it grades on the preoculars, postoculars, and temporals. The labials are as a rule much lighter than above, the color being varying shades of green, yellow, blue, or occasionally white. They are nearly always more or less margined with darker, and there is a tendency, more pronounced in some forms than in others, for one of these dark margins to be extended upward along the anterior margin of the preoculars, and one along the posterior margin of the postoculars, making a conspicuous pattern on the sides of the head.

The ventral surface is ordinarily some shade of slate, often slightly iridescent, and frequently marked with red or black. The bases of the abdominal scutes nearly always possess a varying amount of black which is concealed by the overlying edge of the preceding scute. Where this pigment is well developed it forms a black bar along the base of each ventral scute, which is enlarged at either end into a spot that protrudes beyond the edge of the superincumbent scute, thus giving rise to the appearance of a row of spots along the sides of the belly. In some forms this bar is enlarged in the middle, and frequently to such an extent that it projects beyond the overlying scute and forms a median ventral band that varies in width from a narrow line to a broad band that covers most of the belly (*elegans*, *melanogaster*). The ground color of the belly blends with the color of the dorsal surface on the first row of scales.

RANGE.

The area inhabited by the genus *Thamnophis*, as at present known, includes all of North and Middle America north of the southern boundary of Guatemala and south of the fifty-second parallel of north latitude, although it is possible and even probable that both of these limits are surpassed. These snakes are known from almost every part of the intervening country except the lower part of the peninsula of Lower California[a] and the State of Sonora, Mexico, but the absence of records from both of these localities is probably due to the fact that these regions have been but little explored. The distribution of the different forms will be considered in detail when these are taken up.

HABITS AND HABITAT RELATIONS.

As in the case of most reptiles, very little is known of the habitat relations of the garter-snakes. Where detailed notes are available they will be given in the discussion of the different forms. In general it may be said that while the snakes of this group are not aquatic they apparently prefer the vicinity of water, as they occur in such places much more abundantly than elsewhere, although they are found not uncommonly on higher ground and in dryer situations. The extent to which they prefer damp situations also varies somewhat with the form and the region, as will be shown later.

Their food is in conformity with the nature of their habitat, and varies accordingly. Thus, individuals in the vicinity of water apparently subsist largely on frogs, tadpoles, and fish, while on the dryer uplands they have been observed to eat insects, earthworms, toads,

[a] A single specimen has been recorded from Cape San Lucas, Lower California, but there is good reason to believe that there is an error in this record. (See p. 161.)

small mammals, and fledgling birds. While in captivity it seems to be impossible to get them voluntarily to eat dead food, but in the wild state specimens of three species (*sirtalis*, *radix*, *elegans*) have been observed to take frogs, small mammals, and birds that had been dead for a considerable time.

In the northern part of their range, where cold winters prevail, they hibernate like other reptiles, usually passing the months of December, January, February, and part of March in a dormant condition. The actual time of hibernation is dependent upon the character of the weather, for a few warm days in January or February is sufficient to bring them out. This was well illustrated in the winter of 1906, which was an exceptionally mild one, and garter-snakes were recorded in southern Michigan (Washtenaw County) on January 22. At the approach of warm weather in the spring the garter-snakes are among the first snakes to appear, and may soon be found in numbers in the vicinity of marshes, ponds, and streams, feeding voraciously upon frogs that are so abundant in such places at this time of the year.

But little is known regarding the time of coition, but at least one of the forms (*sirtalis*) is known to copulate in the spring, bringing forth its young in July, August, and September, and, as the other forms for which we have data also bear their broods at this time, the supposition seems justifiable that copulation in most cases takes place in the spring, notwithstanding the statement of Coues (1878, 278) that specimens of *radix* have been observed *in coitu* in September and October. In some instances, at least, they exhibit a gregarious tendency during the breeding season. In 1880, E. L. Ellicott (1880, 206–207) reported having seen an aggregation, in the following words: "I personally had the pleasure of observing it twice, both times very early in the spring, and in localities which could be called wilderness. I first saw such a bundle of snakes in the neighborhood of Ilchester, Howard County, Maryland, on the stony bank of the Patapsco River, heaped together on a rock and between big stones. It was a very warm and sunny location, where a human being would scarcely disturb them. I reasoned that the warmth and silence of that secluded place brought them together. Some hundreds of them could be counted, and all of them I found in a very lively state of humor, hissing at me with threatening glances, with combined forces and with such persistency that stones thrown upon them could not stop them nor alter the position of a single animal. They would make the proper movements and the stone would roll off; all the snakes in this lump were common snakes (*Eutaenia sirtalis* L.)." As Hay (1892 b, 528) remarks, "It is altogether probable that such assemblages are determined partly by the sexual impulses," a view that is confirmed by the fact that in the spring groups do apparently

tend to be formed under the incitement of the sexual stimulus. Indeed Ellicott goes on to say, "The second time I noticed a ball of black snakes rolling slowly down a steep and stony hillside on the bank of the same river, but about 2 miles above Union Factory, Baltimore County, Maryland. Some of the snakes were of considerable length and thickness, and, as I noticed clearly, *kept together by procreative impulses.*" (The italics are mine.)

The young are born alive, the usual number in each brood varying with the age of the snake, in the different forms and possibly in different parts of the range of the same form. (See p. 191.) Dr. J. Schneck (1882, 1008) records a brood of 78 in *sirtalis*, and I have seen as few as four in *butleri*. I have had opportunity of witnessing the birth of hundreds of young garter-snakes of several different species, and as the method was exactly the same in each case observed, there is little doubt but that it varies little throughout the genus. Just before parturition the female stretches out more or less, and may or may not crawl slowly about, but in either case maintains her tail curved slightly upward at the base, thus expanding the anal opening. Distinct labor periods occur, during which the young emerge singly, although a varying number may be extruded in a single labor. In the majority of instances each young is still tightly coiled and invested in the fetal membrane when it appears, exactly as it has laid in the oviduct, although, owing to the occasional bursting of the sac during parturition, they sometimes *appear* to crawl from the anus. After birth the young snake lies quietly for a few seconds and then struggles lustily to thrust its head through the sac. If it is not successful it smothers (which occasionally occurs), but if it succeeds in breaking the sac it yawns once or twice, thrusts out its tongue, and crawls off, becoming at once very lively. As soon as the body becomes dry, the skin is shed, exuviation often beginning within fifteen minutes after the young snake has been ushered into the world.

The young snakes are apparently independent nearly from the first, probably, as Hay (1892 a, 389) has pointed out, owing to the fact that the yolk body is largely consumed before birth. I have never noticed in the case of those born in captivity (*parietalis, sirtalis, butleri, radix, sackeni*) a definite tendency in the young to remain near the mother for a time after birth, as has often been described. They almost immediately crawl away, hiding under sticks, stones, leaves, or other objects. Thus the occasional observations that have been recorded of a mother and her brood in the wild state were probably made immediately after the birth of the latter.

After birth the young snakes are for some time very secretive, and show usually a very decided tendency to conceal themselves under objects, and even to burrow in loose dirt, when in confinement. This is without doubt the reason why specimens of about this age are so

rarely captured. As Abbott (1890, 296–297) says of these and some other snakes, "It is not a little curious that considering the large numbers of eggs that are found in the earlier part of summer so few small snakes are to be seen. I have never come across one less than 4 inches in length, except in the cases of the hog-nose snakes, mentioned above, and of those which I have ushered into day by unceremoniously breaking the egg before the occupants were quite ready to emerge. Even larger snakes, those measuring 6 to 10 inches in length, are by no means common." Abbott is inclined to attribute this rarity of young snakes to enemies, but I believe it to be due, in large part at least, in the garter-snakes, to the retiring habits exhibited by the young snakes during this period of their life. In the case of those observed in captivity this secretiveness lasted until the first winter, and it is probably not until the following spring, at least, that they begin to seek their food in the open. In disposition the garter-snakes vary from the retiring, agile ribbon snakes to the more stocky aggressive species, such as *sirtalis* and *radix*. As a group, however, the adults are not retiring, a feature that combined with their abundance makes them the most common and widely known group of snakes in America.

VARIATION.

I have asserted that the first step in the search for relationships is to determine the variability of the characters. The traits that have been used in systematic work on the garter-snakes are the number of rows of dorsal scales, labial,ventral, and subcaudal scutes, the position of the stripes, comparative length of the chin shields, and proportionate length of the tail. It is now my purpose to subject each of these traits to an examination to determine whether or not they are variable, and, if so, the nature and extent of the modifications or variations.

In investigating the variations it is essential that a distinction be made at the beginning between individual, sexual, and geographic variation, for it is evident that until such a distinction is made we can not hope to determine the value of the traits in pointing out affinities. In systematic mammalogy and ornithology these distinctions are made, but unfortunately in snakes they have been largely ignored. For example, *radix* is generally described as possessing usually 7, but occasionally 8, supralabial scutes. Now it is conceivable that if no distinctions are made that the males might be characterized by 7 and the females by 8, or the opposite, that the variation is purely an individual one, or that there is an increase or decrease in the number in certain parts of the range, and until the actual conditions are ascertained there is little hope of determining affinities, for if in this particular form the variation is individual the

perpetual danger is encountered of correlating it with another in which the labials may also be said to be 7, occasionally 8, but in which this variation is geographic. As another example of this the usual formula given of the ventral scutes of different forms usually includes the extreme variation in number known in the group. It may be easily seen that this also offers no clue to affinities, for any geographic variation in the average that may exist and might serve to connect different forms is in this way completely obscured.

The nature of the variations may be determined of course by taking the mean of the variation for the different sexes in different localities throughout the range, it being necessary to distinguish between the sexes, for if there is considerable sexual variation the predominance of either in the series from particular localities may obscure any geographic differences that may be present. This requires a large series of specimens from each locality, however, which we regret to say have rarely been available in this investigation. However, notwithstanding the fact that sufficient material has not been available in some instances to establish the actual extent of the range of variation of the sexes in the different localities, we believe that the data obtained is in nearly every case sufficient to indicate the nature and trend of the modifications exhibited by the different groups.

Variation in scutellation.—It is not surprising to find that it is largely upon the basis of the scutellation that most of the forms of *Thamnophis* have been defined, for the number of scale rows, labial, ventral, and subcaudal scutes have long been regarded by herpetologists as available specific characters. Indeed, as will be brought out in the following discussion, these traits are, within limits, sufficiently stable to admit of their employment as diagnostic characters in the different forms of garter-snakes. Inasmuch, however, as similarity in the number of scales has been held to indicate genetic relationships, it is necessary to investigate the variations which they exhibit.

The number of rows of dorsal scales has undoubtedly been considered the most important systematic character in the determination of the different forms of this genus, as well as in many other groups of snakes. When an individual snake is examined these rows are found to be arranged in longitudinal series, running the entire length of the body, from the head to the tip of the tail. The scales of the different rows are alternately arranged, so that transverse as well as longitudinal series are formed.

Variation in number of dorsal scale rows.—The number of longitudinal scale rows on the body, i. e., anterior to the vent, is normally an odd number, as the series are usually paired on either side of a median dorsal row. If a specimen of some species (*sirtalis*, for example) be examined, it will be found that on the anterior half of the

body there are 19 rows of scales. If these rows be traced backward somewhat beyond the middle of the body, however, it will be noticed that a row is dropped on either side at approximately the same place, leaving 17. The decrease posteriorly in the number of scale rows, thus described for *sirtalis*, occurs in all of the garter-snakes, and the number usually given in diagnoses as typical of the different forms (23, 21, 19, or 17) is in every case the maximum number of rows, which, as we have just indicated, always occurs on the anterior half of the body. Furthermore, an examination of large series of these snakes has established beyond question *that the decrease in the number of scale rows posteriorly is brought about in all of the forms of garter-snakes by the loss of certain definite rows.* On all of the specimens examined with a maximum number of 23 scale rows anteriorly (*megalops*), which is the largest number that occurs in the genus, the fifth is first discontinued posteriorly, leaving 21, and shortly afterwards the sixth (now the fifth) leaving 19, and finally the fourth, leaving 17. In the specimens with 21 rows (*elegans, radix,* and *hammondi*, for example) it is the fifth row that is dropped first to leave 19, and then the fourth to leave 17. In those with 19 rows (*sirtalis, eques, sauritus*, etc.) the fourth is dropped posteriorly to leave 17, while when the maximum number of rows tends to be less than 19 (*butleri, ordinoides*, and *scalaris*) the fourth row drops out first to leave 17 and then the fifth (now the fourth) to leave 15.

It will be seen at once *that the order in which the rows are lost posteriorly in the different forms is the same as in the form having the maximum number of rows for the genus.* In fig. 1 a diagram has been constructed to show this law of reduction as it would be represented on a snake having a maximum number of 23 rows anteriorly and a minimum of 15 posteriorly—the extreme range of variation in the genus. An examination of this diagram shows that although the order in which the rows are lost is, when counted from the ventral series each time, as is usually done, 5, 5, 4, 4, the real sequence when expressed in terms of the maximum number of rows for the genus is 5, 6, 4, 7. The diagram also illustrates the manner in which the rows are lost, for in the great majority of cases the scales of the row which is dropped become smaller and finally cease, the adjacent rows converging to occupy the space. At the point where the row is discontinued there is often, however, a rather large scale bearing two keels, indicating that the last scale of the lost row has fused with its neighbor. In case such a fusion occurs it may be either with the row above or below, but the fact that the scales of the row to be dropped usually become smaller toward the termination of the series, and that the keel of this row is usually only on the edge of the large scale, generally denotes clearly which row is really lost.

The decrease in the number of scale rows posteriorly is, we believe, correlated with the taper of the body, for as the scales themselves decrease but little in size toward the tail the loss of the rows is a necessary result of the shortening of the metameres. Furthermore, as shown above, the reduction posteriorly takes place caudad to the middle of the body, i. e., where the body tapers to the tail. This phenomenon may not in itself be considered important, but, as will be shown directly, it has a wider significance than as an explanation of the manner in which the scutellation accommodates itself to the posterior diminution in the size of the body.

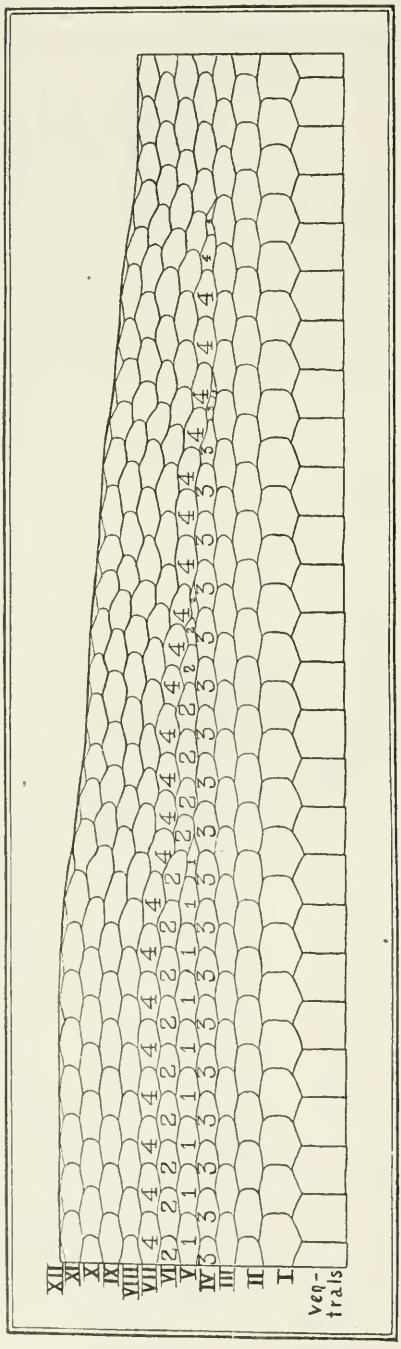

FIG. 1.—DIAGRAM ILLUSTRATING THE ARRANGEMENT OF THE DORSAL SCALE ROWS IN THE GARTER-SNAKES. THE FIGURE MAY BE TAKEN AS REPRESENTING A SECTION OF THE TRUNK, EITHER ANTERIOR OR POSTERIOR FROM THE MIDDLE OF THE BODY, OF A HYPOTHETICAL INDIVIDUAL WITH THE MAXIMUM AND MINIMUM NUMBER OF ROWS FOR THE GENUS.

In certain forms the maximum number of scale rows is known to be very constant. For example, specimens of *sirtalis*, *eques*, *proximus*, *sauritus*, or *sackeni* are but very rarely found that have either more or less than 19 rows anteriorly, but, notwithstanding the fact that most of the other forms are also usually described as having a definite number of scale rows, there is considerable variation in this respect. If a specimen of *megalops* with a maximum number of 23 rows be examined it will be found that this number only occurs on the middle of the body, owing to the fact that the fifth row is dropped anteriorly as well as posteriorly, thus making a formula of 21–23–21–19–17, counting the

maximum number of rows on the different parts of the body.[a] Similarly also in variable forms that have a maximum number of 21 rows, the fifth is often dropped anteriorly as well as posteriorly, giving a formula of 19–21–19–17. In the forms having a maximum of 19 rows the formula may be 17–19–17–15, with the fourth row shortened anteriorly as well as posteriorly, while in those in which 17 is the maximum it is also the fourth that is dropped anteriorly when there are but 15 anteriorly. The abridged row when shortened anteriorly varies in length, and may extend nearly to the head or be abbreviated so as to include but a few scales on the middle of the body. This suggests at once that among the specimens in a given locality those in which a certain row is dropped anteriorly as well as posteriorly represent an intermediate condition between those in which this row is continued to the head and those in which the maximum number is one row on either side less than the maximum for the locality, the decrease being brought about by the loss of the first abridged row in the maximum formula. To illustrate, individuals of *radix* from the vicinity of St. Louis, Missouri, may have the formula 21–19–17, 19–21–19–17, or 19–17, the length of the fifth row varying in the specimens with 19–21–19–17 rows from a few millimeters to include the entire anterior half of the body, and we can only conclude that the formula 21–19–17 is a result of the continuation of this row to the head, while in specimens with 19–17 rows it is entirely lacking.

It is thus the first abridged row that is shortened and lost in the decrease in the number of scale rows, and as this row, as we have previously seen, generally ends a little beyond the middle of the body, it is evident that most of the shortening must take place at the anterior end of the row. There is, however, a posterior shortening of the second abridged row, for upon the disappearance of the first short row the second abridged series becomes the first, and its posterior end must move up toward the middle of the body to retain the symmetry. This variation in the maximum number of scale rows may be summarized as follows: *The decrease in the number of rows of dorsal scales among the garter-snakes of a given locality is due to the anterior shortening and subsequent loss of the first row of scales that is dropped posteriorly in each snake having the next higher scale formula.*

I have been unable to discover any sexual variation in the number of scale rows, but in many cases an examination of large series reveal distinct geographic differences in this regard. Thus in the great plains region *radix* exhibits the scale formulas 21–19–17 or 19–21–19–17, but in the prairie region to the east a decidedly larger proportion of specimens have 19–21–19–17 rows, while near the eastern limits of its range the formula 19–17 is occasionally

[a] In the following paper the rows will be numbered from the gastrosteges each time.

encountered. More than this on the eastern boundary the species is replaced by a smaller form (*butleri*) which is not known to have a higher formula than 19–17. I will not take the space here to give further illustrations, as they will develop in the consideration of the various forms. It is sufficient to say that the geographical variation in the number of scale rows, shown to occur in *radix*, also occurs in many other forms in the genus. Since the geographic variation in the number of scale rows is brought about in the same manner for the various forms as in the individuals of a given locality, and it further develops that these forms at points in their range where the number of scale rows is at a minimum or maximum often grade into, or are replaced by, other evidently nearly related forms with a smaller or larger number of rows, the conclusion seems to follow that the *racial differences in the number of dorsal scale rows in the garter-snakes are the result of the loss of the abridged rows in the order in which they are dropped posteriorly in individuals that have the maximum number of rows for the genus.*

At first sight it appears rather odd that the first abridged row should end so constantly just beyond the middle of the body, and that any further decrease should take place from the fore backward, but an explanation presents itself. As has been previously stated, the reduction in the number of rows posteriorly is correlated with the taper of the body. If, therefore, we consider that there is also a slight decrease in the size of the body anteriorly that culminates in the constriction of the neck, the tendency for the rows to drop out anteriorly may be considered analogous to their abridgment posteriorly. This anterior taper is slight and not sufficient in many specimens to make a difference in the number of rows between the neck and body, in which case the first abridged row extends to the head, but it is apparently such that a decrease in size would effect the scale rows here before on the middle of the body. There is no noticeable difference in the size of the scales between individuals with a greater or fewer number of scale rows, but it is very noticeable that those forms which possess the smallest formula in the genus are distinctly the smaller in size, and the opposite. It seems safe to conclude, therefore, that the loss of the rows is correlated with a general decrease in the size of the body, and that in the decrease the number of rows is influenced by the necessity of maintaining the symmetry of the body, so that the decrease is noticeable first on the anterior and posterior parts of the body, owing to the comparatively smaller size of these parts. Whether or not such dwarfing takes place we will be more able to judge when the evidence of the other characters and the forms themselves have been examined.

However, since, as I shall show later, the males are smaller, more elongate and less stocky in form than the females, a tendency toward a reduction in the number of scale rows should, it seems to me, be revealed first in the former sex. This point is difficult to test, for extensive series are wanting in most regions where such a reduction is inaugurated, and in a region where the reduction is great enough to markedly influence the females the difference between the sexes would be obscured, since there is not enough difference in relative size to give the males the next lower formula. A series of specimens of *radix* from Palo Alto and Clay counties, Iowa, however (where, as will be shown later, there is a slight tendency toward a reduction in the number of scale rows from 21–19–17 to 19–21–19–17), seem to confirm our reasoning, for out of seventeen males thirteen have the formula 19–21–19–17, as against 21–19–17 in the others, while out of thirty-five females but six have this formula, the remainder having 21–19–17. This matter should receive further study.

The law of variation to which the scale rows are subject may be formulated as follows: *The individual, geographic, and racial variations in the number of dorsal scale rows in the garter-snakes is brought about by the shortening and loss of the same scale rows as are ordinarily dropped posteriorly in conformity with the taper of the body, and there is evidence that this decrease is due to a dwarfing of the body.*

It should be pointed out that the adjustment of the scale rows to the taper of the body shown in these snakes is very similar to the plate arrangement observed in certain Palæechinoids by Jackson and Jagger (1896). If our diagram (fig. 1) be compared with their diagram of the ideal arrangement of interambulacral plates in *Melonites multiporus* (p. 164) it will be seen that the rows dropped posteriorly in the snakes are almost exactly in the middle (of each side), as the rows of interambulacral plates which are discontinued toward the ventral end in the echinoids are in the middle of the interambulacral area, so that the order in which they are dropped in the snakes and echini is exactly the same. In the echinoid figured, owing to the pronounced constriction dorsally, the columns of plates are distorted, but continue to be represented—a feature that is not shown in those garter-snakes in which the maximum number of rows continues to the head, possibly because the constriction of the neck is too slight to disturb the rows. That a dying out of columns also occurs in echinoids, however, is stated by Jackson and Jagger, and it is very interesting to note that "when columns die out or cease to be continued to the dorsal area it is commonly the middle or last added column which drops out first in the cases observed," which is exactly analogous to the dropping of the scale rows anteriorly in the garter-snakes.

Variation in number of labial plates.—The number of labial plates (fig. 2) in the garter-snakes varies from 6 to 9 above the mouth and 8 to 11 (very rarely 12) below, each of the numerous forms tending to have a certain definite number, as in the case of the scale rows. For the latter reason the number in each of these series is often used as a diagnostic character, but, owing to the fact that individual variations are not uncommon, this trait has been accorded only secondary importance, while of the two the number of supralabials is considered of more taxonomic importance, as it is noticeably less variable. There seems to have been little attempt, however, to determine the nature of these variations.

In almost any locality a series of specimens [a] will reveal differences in the number of these plates. Thus, in *proximus*, while the labial formula [b] in the great majority of specimens from the same region is 8/10, there may be 7 upper and 9 or 11 lower labials. In *sauritus* the formula is mostly 7/10, but specimens with 8 superior and 9 or 11 inferior labials occasionally occur. Again, *ordinoides* specimens from the same locality may have 6, 7, or 8 superior and 8, 9, or 10 inferior labials. The variability shown by these forms is typical of all of the forms in the genus, and it will be seen at once that the amount of individual variation is very slight. In the case of the lower labials the difference indicated in the specimens from the same locality may consist of both a loss and an addition of a scute to the normal number for the locality, but it rarely exceeds this amount. In the case of the supralabials, however, the difference shown by specimens from the same locality usually consists of either an increase or decrease of one scute, it being rarely that the variation occurs both above and below the normal number for the region.

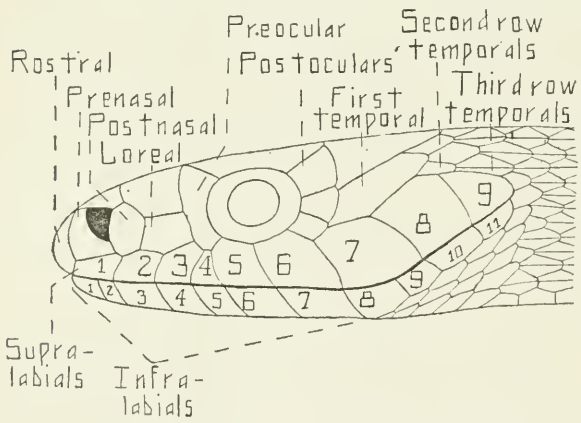

FIG. 2.—THE ARRANGEMENT OF THE HEAD PLATES IN THE GENUS THAMNOPHIS, AS REPRESENTED IN AN INDIVIDUAL POSSESSING THE MAXIMUM NUMBER OF LABIAL PLATES FOR THE GENUS.

This apparent definiteness in the variation in the number of upper labials at once suggests the presence of some controlling factor. It

[a] The following discussion may be followed on the diagram that forms fig. 3.

[b] The labial formula is the number of scutes in each series, and is expressed as a fraction; for example, 8/10 means 8 supralabials and 10 infralabials.

can not be sex, for in no instance where large series have been examined has it been possible to detect any correlation between the number of labials and the sex of the specimens. On the other hand, when the racial differences are examined the apparent definiteness in the individual variation of the upper labials is seen to be extended also to the lower. Thus, in *proximus*, which as a form has 8, occasionally 7, supralabials, and 10, but also 9 or 11, infralabials, the presence of 9 lower labials occurs much less frequently than 11 throughout most of the range, while in *sauritus*, on the other hand, in which the upper labials are 7, occasionally 8, and the lower 10, occasionally 9 or 11, specimens with 9 infralabials are much more abundant than those with 11. *Sauritus* thus exhibits a tendency toward a smaller number of lower as well as upper labial scutes than *proximus*. Furthermore, where the ranges of these forms meet and the forms intergrade (in Illinois, for example), the specimens appear to be about equally divided in the possession of 7 or 8 supralabials, while the infralabials are normally 10, with the occasional variations 9 and 11 about equally disposed. This at once suggests that these variations are geographic.

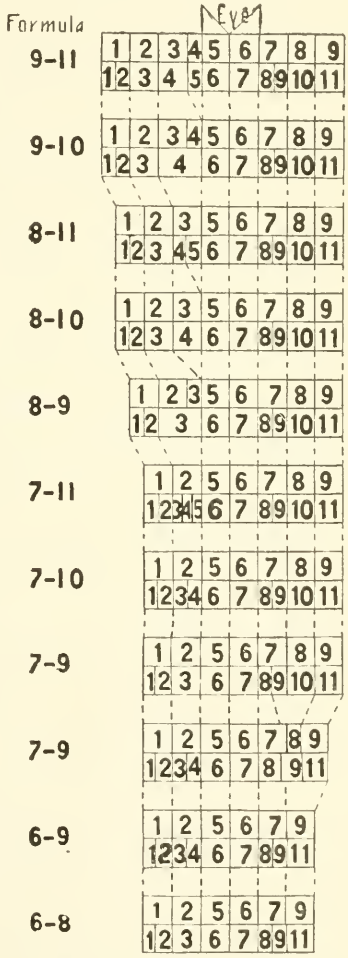

FIG. 3.—DIAGRAM SHOWING THE METHOD OF VARIATION IN THE NUMBER OF LABIAL SCUTES THAT RESULTS IN THE FORMULAS CHARACTERISTIC OF THE DIFFERENT FORMS OF GARTER-SNAKES.

It is difficult to demonstrate a geographic variation in the number of labial scutes within the different forms, for the amount of the individual differences is usually equal to any geographic variations that exist in the same form. This necessitates the examination of large series of specimens to obtain as near as possible the mean number for each locality, for in small series of specimens slight fluctuations in the locality averages, due to the accidental preponderance of specimens with the same number, are sufficient to obscure any geographic trend in the variations. In certain intergrading forms, however, it is possible to show that geographic differences do occur within the form. There is good reason to believe,

for example, that the forms known as *elegans* and *ordinoides* intergrade in eastern Washington and Oregon, *elegans* extending to the east of this region and *ordinoides* westward to the coast. In *elegans* the labials are normally 8/10, but in *ordinoides* they are generally less, so that there is evidently a decrease in the number of these plates in the region where these forms intergrade. This is shown when specimens from the eastern part of the range of *ordinoides* are examined. Thus, on the eastern shore of Puget Sound the upper labials in this form are 7 or 8 (rarely 6), the infralabials 8, 9, or 10, the average for the upper labials in a large series being 7.2, for the infralabials 9. Toward the west coast, however, the number decreases very noticeably, the occurrence of 8 upper and 10 lower labials becomes rarer, the formula tending to become 7/8. This not only indicates a difference between two forms in the number of plates, but also a geographic variation in this trait within the form *ordinoides*. As will be shown later, this occurs in several other forms, and there seems to be good reason, therefore, for concluding that *whatever the factors may be that influence the number of labial plates, the variations are geographic and have been the basis for the racial differences that now exist.* This will come out much more clearly in the consideration of the various forms.

In attempting to discover the factors involved in the variations in the number of labials it is necessary to inquire more closely into the nature of the latter. In the first place it must be noted that the number of upper and lower labials are correlated. For example, in a series of specimens of *ordinoides* from Puget Sound, Washington, all but two out of fifteen individuals with 7 supralabials have 9 inferior labials or less, while out of the eight with 8 upper labials six have 10 inferior on both sides and one 10 on one side and 9 on the other. In most cases, however, the range of individual variation is too small to show this correlation, and it can only be noted in a general way. Thus, a review of the different forms shows that in those with 8 superior labials the inferior labials are normally 9, 10, or 11; in those forms, in which the number of supralabials is 7, the infralabials are 8, 9, or 10, while in those with 6 in the upper series there are usually 8 or 9 in the lower. Thus, although not exact, a correlation between the number of superior and inferior plates very evidently exists, and it can be said that *generally there are normally two or three more scutes in the lower series of labials than in the upper, but rarely less or more than this number.*

This correlation might well be expected from the fact that these two series of scutes border the mouth exactly above and below on either side, and as they thus have the same relative length in each snake, any difference in the length of one series must evidently be correlated with an increase or decrease in the length of the other, and

also in the size of the mouth. While this is true it does not follow, however, that a difference in the size of the mouth is of necessity associated with a difference in the *number* of labials, for it is conceivable that the same result might be attained by an increase or decrease in the size of the individual scutes, without disturbing the number, or the number of plates in each series might be increased or decreased by division or fusion without modifying the size of the mouth. It is necessary, therefore, to determine the method by which variation in the number of labial plates is brought about before the significance of the differences can be discovered.

I may be taken to task for asserting that variations in the number of labials are caused by a decrease in the size and ultimate disappearance of certain plates, for instances of the division and fusion of individual scutes will have been recognized by anyone who has handled a considerable number of these snakes. If, however, the frequent abnormalities, to which all large scales in snakes are subject, be ignored, we believe that it can easily be demonstrated that the normal method of variation in the labials is associated with the decrease in size and ultimate disappearance of certain plates.

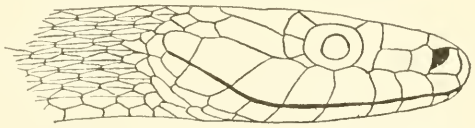

FIG. 4—THAMNOPHIS MEGALOPS (1008 FIELD MUSEUM) SHOWING THE NORMAL ARRANGEMENT OF THE LABIAL SCUTES WHEN THE FORMULA IS 8 10.

As was stated in the general description of the scutellation in the genus, the eye rests directly upon the supralabials, the orbit being above the suture[a] of two adjacent scutes, fig. 2. These labials are said to "enter the orbit," and the particular scutes thus situated are often mentioned in diagnoses. Thus, in *proximus* the fourth and fifth labials enter the orbit, in *sirtalis* the third and fourth, etc. If, however, the relative position of the eye to the supralabials be investigated in the different forms, in connection with the number of scutes in this series, it very soon develops that the general statement can be made that *in all of the forms of garter-snakes with more than 7 supralabials the orbit is bounded below by the fourth and fifth scutes of this series; in those with 7 or less it is the third and fourth that enter the orbit.*

This may mean one of two things, either the position of the eye is constant relative to the two scutes which bound its orbit, and the difference in the number of labials occurs anteriorly, or the variation in the number of labials has taken place behind the eye and has been associated with a change in the position of the orbit. If the position of each superior labial be examined on any snake in which there are 8 in the series, it will be found (fig. 4) that the first

[a] In *angustirostris*, in which the orbit is separated from all but one labial by the forward prolongation of the lower margin of the lower postocular, the relative position of the eye is the same, as it is still directly above the suture of two labials.

extends from the rostral to some point below the posterior nasal scute, the posterior margin of the second ends under the loreal, the third under the preocular, the fourth under the eye, the fifth under the postoculars, the sixth under the first temporal, the seventh under the second temporal, and the eighth under the second scale behind the first temporal, which may be termed, for convenience, the lower scale of a third row of temporals. In all of the forms with a normal number of 8 supralabials this arrangement is the rule, and specimens are seldom observed in which the margins of the scutes are outside of the limits of the plates mentioned above, although slight deviations in this way do occasionally occur. Now, when there are 9 supralabials, as in many specimens of *megalops*, the margin of the extra scute in every case observed is situated entirely within the limits of the preocular (fig. 5). This is always smaller than the adjacent scutes, and is always and only present when there are 9 labials in the series, so that there can be no question that it is the one that is added.

FIG. 5.—THAMNOPHIS MEGALOPS (1098 FIELD MUSEUM), SHOWING THE SMALL SIZE OF THE FOURTH SUPRALABIAL WHEN THERE ARE NINE IN THIS SERIES.

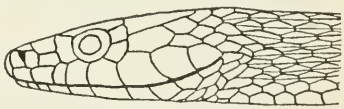

FIG. 6.—THAMNOPHIS ORDINOIDES (1109 FIELD MUSEUM), SHOWING THE REDUCED THIRD SUPRALABIAL—THE FIRST STAGE IN THE REDUCTION FROM 8 TO 7.

If now a series of specimens of any form in which the supralabials are normally 7 and occasionally 8 (*radix*), or usually 7 and frequently 8 (*ordinoides*), be scrutinized, it will often be noticed that in the specimens with 8 the third is frequently decidedly narrower than the second or fourth (fig. 6). Both in front and behind the eye in such specimens the supralabials are arranged exactly as in those which have normally 8, except that the common suture of the second and third occurs near the posterior margin of the loreal, thus narrowing the third plate very decidedly. In these forms when there are but 7 scutes there is either no labial suture below the loreal, the second plate extending from the posterior nasal to the preocular, or the posterior margin of the first labial is moved slightly backward so as to lie under the extreme anterior part of the loreal (fig. 7). There can be no doubt, therefore, that the decrease in the number of supralabials from 8 to 7 is in these cases due to a loss of the third scute and that the method of this loss consists principally of a narrowing of this

FIG. 7.—THAMNOPHIS SAURITUS (32972 UNIVERSITY OF MICHIGAN MUSEUM), SHOWING THE NORMAL ARRANGEMENT OF THE LABIAL SCUTES WHEN THE FORMULA IS 7.7.9.

plate. That fusion also plays a part is also very evident, however, as illustrated by fig. 8, but that this usually takes place only when the plate in question has become much reduced in width also appears evident, for specimens have not been observed in which either of the adjacent plates were strikingly enlarged, as must have been the case had this plate fused with either of its neighbors before becoming reduced. The fact that the adjacent plates are not noticeably larger in specimens with 7 than in those with 8 supralabials also makes it very probable that with this loss of a supralabial in front of the eye there is associated a shortening of the muzzle. In forms which have normally 7 the arrangement is exactly the same as in specimens with 7 in the forms which have 7 or 8 (fig. 9).

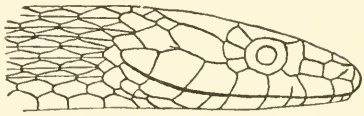

FIG. 8.—THAMNOPHIS ORDINOIDES (1109 FIELD MUSEUM), SHOWING THIRD SUPRALABIAL REDUCED AND PARTLY FUSED WITH THE FOURTH TO LEAVE SEVEN.

FIG. 9.—THAMNOPHIS SIRTALIS (30820 UNIVERSITY OF MICHIGAN MUSEUM), SHOWING THE NORMAL ARRANGEMENT OF THE LABIAL SCUTES WHEN THE FORMULA IS 7/10.

There is but one form (*butleri*) in which the supralabials are very frequently 6, but *radix* (and apparently also *ordinoides*) occasionally exhibits a tendency to have less than 7. If a specimen of *radix* or *butleri* (fig. 10) with 6 labials be examined, it will be found that the first four scutes are arranged exactly as in specimens with 7 (fig. 7). The fifth plate, however, is somewhat wider than usual, extending to beyond the middle of the first temporal instead of in front of it, while the next, which is now the last, extends to the middle of the third as usual.[a] In *butleri*, and frequently in *radix*, when there are 7 labials the same arrangement of the scutes is adhered to, except that the fifth in these individuals extends from the postocular to a point in front of the middle of the first temporal (its normal position in forms with 7 scutes in this series), while the next extends from here to beyond the middle of this scute, the last retaining the position which it has in specimens with 6 labials (fig. 11). It would seem from this that the decrease in the number of labials from 7 to 6 has resulted from

FIG. 10.—THAMNOPHIS BUTLERI (226 RUTHVEN COLLECTION), SHOWING THE LARGE FIFTH SUPRALABIAL CAUSED BY THE DECREASE IN SIZE OF THE PENULTIMATE SCUTE AND ITS FUSION WITH THE ANTEPENULTIMATE LABIAL.

[a] In many specimens of *butleri* the last labial ends below the single large second temporal, but this scute has very evidently been formed by a fusion of the scales which usually constitute the first and second rows behind the first temporal, so that the relative position of the posterior margin of the last supralabial in respect to these scales is the same as in other forms which do not have a single temporal in the second row.

the fusion of the penultimate and antepenultimate scutes. While such a fusion undoubtedly exists, however, it constitutes but a part of the story; for, if simply a fusion of these scutes took place, the fifth, in individuals with 6 labials, should extend from the postocular to the second temporal, while, as it is, it only extends a little beyond the middle of the first temporal, being thus but slightly larger than in specimens with 7. A reduction in the size of the penultimate scute must therefore take place at some time during the process of reduction in the number from 7 to 6. A series of specimens of *butleri* and *radix* from the common boundary of their range, where, as we have seen, a reduction in the number of labial plates from 7 to 6 takes place, will illustrate this process in all of its stages. Thus, in most of the specimens with 7, the penultimate scute extends from the anterior part of the first temporal to the second row of temporals, the normal arrangement for this number of labials (fig. 9). In other specimens (fig. 11) this labial extends only from the anterior part of the first temporal to beyond the middle of this scute, while in still others the reduced penultimate scute is partially fused with the antepenultimate one (fig. 12). As the posterior margin of the penultimate plate, in specimens with 6 labials, generally comes in contact with the first temporal at about the place where the posterior margin of the sixth occurs in the specimens in which it is much reduced, the next step in the reduction of this plate would seem to be its entire fusion with the preceding scute to leave 6 (fig. 10).[a] Therefore *the reduction in the number of labial scutes from 7 to 6 in the garter-snakes is brought about by the narrowing and loss of the sixth; and as there is not a corresponding increase in the size of the neighboring scutes, this decrease in the number of labials must be accompanied by a shortening of the mouth behind the eye.*

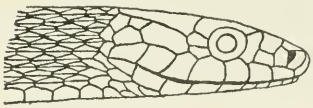

FIG. 11.—THAMNOPHIS RADIX (155 RUTHVEN COLLECTION), SHOWING SIXTH SUPRALABIAL NARROWER THAN USUAL AND ENDING ON THE FIRST INSTEAD OF THE SECOND TEMPORAL.

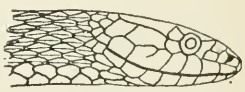

FIG. 12.—THAMNOPHIS BUTLERI, SHOWING THE LAST STAGE IN THE LOSS OF THE SIXTH SUPRALABIAL—THE FUSION OF THE REDUCED SCUTE WITH THE FIFTH.

From its apparent general occurrence among the different forms, the above described method of variation in the number of supralabials may be formulated in the following general terms: *A reduction in the number of supralabials takes place in the garter-snakes as a*

[a] I have previously noted (Ruthven, 1904, 294) that when there are 7 supralabials in *butleri*, the extra one is apparently formed by the division of the fifth. The explanation for this is now shown to lie in the method of reduction in the number of these scutes from 7 to 6.

result of the narrowing and final loss of the fourth, third, and eighth scutes consecutively, as numbered on a snake with 9 plates in this series.

I have previously noted that the number of labials in the upper and lower series is correlated, and that a reduction in the supralabials is associated with a decrease in the number of infralabials. The method of reduction in the number of the inferior labials is, however, somewhat more obscure, for, owing to the small size of these plates, it is often difficult to detect any decrease in the size of individual scutes, so that in forms with a different number of scutes in the lower series it is very difficult to say just which plates have been lost. Much light can be thrown upon the problem, however, by correlating the position of the individual plates of the two series.[a] If a specimen of *megalops* with the labial formula 9/11 be examined it may be noted that the upper margin of each individual scute in the lower series corresponds almost exactly in width and position to one in the upper series, except that the first and seventh supralabials are above two scutes in the lower series. This arrangement is quite accurately maintained in all of the specimens with this formula examined. If, however, a specimen with the labial formula 9/10 be scrutinized it will be found that, while the same arrangement is for the most part adhered to, the small fourth labial has not in these specimens a corresponding infralabial, but that the preceding infralabial scute (the fourth) extends backward to the posterior margin of the fourth supralabial (fig. 5). Evidently, then, either the third or the fourth infralabials are not present in these specimens, or they have fused into a single scute. Just which method prevails is immaterial, for we hope to show that in other cases, as well as in this one, the reduction in infralabials always takes place beneath the upper labial scute that is being reduced; and as was seen in the case of the upper labials that the upper scute is first reduced and finally fused, it may be taken for granted that it is the corresponding infralabial that is lost.

In specimens with the labial formula 8/10 the third superior has a single corresponding inferior labial scute (fig. 4), and there is in such specimens a condition exactly similar to 9/11 forms, except that the fourth supralabial and its corresponding infralabial (the fifth) are lost. In those rather rare cases where the formula 8/11 is shown, it is interesting to note that there are two infralabials below the third supralabial, so that the arrangement is exactly similar in 9/11 forms except that the fourth supralabial only has disappeared.

In the specimens that show a tendency toward a reduction in the labial formula below 8/10 the third superior, as already noted, becomes

[a] The points brought out in the following discussion are illustrated in the diagram (fig. 3).

noticeably smaller. In such specimens when the formula is 8/9, the reduced third superior scute (as in the case of the reduced fourth in the formula 9/10) has not a corresponding inferior labial, but is included within the limits of the preceding inferior scute, which also underlies the second supralabial. Here again is a loss of an inferior labial scute corresponding in position to a reduced superior labial.

As already seen, it is the reduced third supralabial that is lost to make 7 upper labials, and in the specimens with the formula 7/9 the disposition of the inferior plates in front of the eye is exactly as in the formula 8/10, except that the inferior labial corresponding to the third supralabial in the 8/10 specimens is lacking (fig.7), and likewise the same as in 9/11 specimens, except for the loss of the fourth superior and its corresponding inferior scute. In specimens with the formula 7/10 (fig. 9), a fourth infralabial is present, but with the third lies entirely under the second supralabial, while in 7/11 a third, fourth, and fifth may be seen beneath the second supralabial.

Up to this point the reduction in the number of inferior labials, as in the case of the upper labials, has taken place in front of the eye. When the labial formula is 7/9, however, and the penultimate superior labial is narrowed, there is likewise a reduction in the width of the penultimate scute in the inferior series. When the small penultimate supralabial has disappeared, leaving 6, an infralabial scute also tends to disappear, leaving 8, and the same arrangement as in 7/9 specimens is attained, i. e., each superior labial except two are situated above an infralabial (fig. 10); but in this instance it is the first and penultimate supralabials which have two corresponding inferior scutes, instead of the first and antepenultimate, as in other instances. In this instance, however, it frequently does not appear that the lost inferior labial is the one corresponding in position to the lost supralabial, for in many 7/9 specimens in which the penultimate supralabial is reduced in size the penultimate inferior labial extends partly under the antepenultimate superior scute, thus occupying the place of the posterior small inferior labial that usually underlies this scute and with which it has evidently fused. The penultimate infralabial is, however, first reduced in size at the same time that the corresponding supralabial is pushed forward in the process of reduction, so that it may be considered as the one that is lost in the reduction in the number of infralabials from 9 to 8.

The reduction in the number of lower labial scutes in the garter-snakes thus takes place in exactly the same manner and at about the same time and place as the decrease in the number of superior labials, which explains the existing correlation in the number of plates in the two series. Examining the diagram (fig. 3) as a whole, it may be seen (1) that the reduction in the two series takes place at about the same time and place, and in the following order from the maximum number:

4/5, 3/4, 8/10; (2) that the loss of the scutes in both series takes place first in front and then behind the eye, which retains the same position in regard to the superior and inferior plates; (3) that as the reduction consists of a decrease in the size, and final loss, of the disappearing scutes, without a corresponding increase in the size of the remaining scutes, a contraction of the mouth is necessarily associated with the decrease in the number of labials. We can even go farther than this, however, for in these snakes the posterior angle of the mouth extends practically to the posterior angle of the jaw, which in turn marks the extreme posterior limit of the head. This is shown externally by the fact that the cephalic plates never extend beyond the posterior angle of the mouth. Since the number of labials is correlated with the length of the mouth, which extends the entire length of the head, it logically follows that the number of labials is also an expression of the head length.

It is very difficult to prove the existence of any geographic or racial differences in the length of the mouth or head by actual measurements, as these differences must in most instances be very slight, as indicated by the limited range of the variations in the number of labials. It is apparent, however, that such differences exist, for two forms, *butleri* and *ordinoides*, are characterized by the noticeably small size of these features, and it is to be noted that besides being the only forms in the genus with a decidedly small mouth and head, these forms also possess the smallest number of labials, and if a comparison be made between these rather extreme forms and their nearest relatives, *radix* and *elegans*, a difference in the length of the head and mouth may be readily seen.

From the above discussion of the method of variation in the number of labials the law of labial reduction for the genus may be formulated as follows: *The differences in the number of labial plates in the garter-snakes is the result of the loss of corresponding superior and inferior labial scutes, the loss taking place both in front and behind the eye, thus resulting in a shortening of the mouth and head toward this organ.*

Variation in number of ventral and subcaudal plates and in proportionate tail-length.—As previously stated, there is a single series of large scutes on the belly and two rows of smaller ones on the ventral surface of the tail. The number of scutes in each of these series has been considered of systematic importance, and it is true that each form has a definite number within limits. The range of individual and sexual variation is so great, however, and the racial differences generally so slight that large series must be examined from each locality to determine geographic variation.

The number of ventrals is apparently less variable than the subcaudals. There is some sexual difference, as may be determined by an examination of a series of specimens from any locality, but the

limits of this variation overlap considerably owing to the individual variation. Thus, in a large series of *radix* from Clay and Palo Alto counties, Iowa, the ventrals in the females range from 148–166, in the males from 160–172. In order to determine whether or not geographic variation occurs in a species it is necessary to note the proportion of sexes in the locality averages, since a predominence of either obscures slight geographic differences. It can be shown, however, that geographic variation not only exists but that it is correlated with the reduction in the scutellation shown above. Concrete examples will be brought out in considering the different groups. It is only necessary to point out here that all of the forms which have a much reduced number of dorsal scales and labial plates have also a proportionately small number of ventral plates, and the opposite.

On account of their greater variability, therefore, the number of scutes in this series is a trait which is less useful to the student than the number of dorsal scale rows and labial scutes, and, while by no means valueless, is to be used principally to substantiate the evidence of the other characters, when allowance has been made for the disturbing factors of individual and sexual variations.

The variation in the number of subcaudals is of the same nature as that of the ventrals in that the number is greater, as a rule, in males, the extremes of variation in the two sexes overlap, and the individual variation is considerable. In the case of the urosteges, however, the number is not always correlated with the reduction in the scutellation, but with the tail length, which may vary to some extent irrespective of the body. The most pronounced case of this is in the intergrading varieties of the ribbon-snake group. *Sauritus* in Michigan has a proportionately longer tail and more subcaudals than the southwestern form *proximus*, which has more ventrals and labials and attains a much larger size. The character has thus always to be checked up with measurements, but it is not valueless, for when the same proportionate length of tail is maintained the number of urosteges is correlated with the rest of the scutellation. Happily the proportion of tail to body length is quite constant throughout the genus; the only exception being the ribbon-snakes, which usually have a tail length of .27–.38 of the total length and are sharply separated by this and the large number of urosteges from the rest of the species in the genus, which have a tail length of .19–.27, the females of the former approaching the males in the latter.

Variation in number of preoculars and in arrangement of lateral spots.—The number of preoculars has been employed but little in specific diagnoses, although it has been used frequently in descriptions. The explanation for this is to be found in the fact previously stated that in most of the species in the genus there is but a single plate in front of the eye. Certain forms, however, (*me-*

lanogaster, angustirostris, hammondi, ordinoides, and *elegans*) either quite constantly or in some part of their range, exhibit more than one preocular. Whatever may be the cause of this division of the preocular, other evidence, as will be shown later, appears to indicate plainly that these forms are closely related, so that the presence of two or more preoculars over all or a part of the range separates them from all others in the genus.

Although the arrangement of the lateral spots are usually referred to in descriptions, the character is entirely too variable to be used extensively in diagnoses. As before stated, when distinct they are in the form of two rows of alternating spots on either side between the stripes. In forms where they are ordinarily distinct, however, they may be fused to a variable extent in melanic individuals, while being more than usually prominent in light-colored ones. While they are thus quite variable individually, they also exhibit some racial differences. Thus, in *parietalis* the upper row is usually fused into a band, and in *eques*, *sirtalis*, and *parietalis* the first few anteriorly frequently tend to fuse with their neighbors in the opposite row to form crossbars. In two forms the arrangement has become modified into a series of transverse blotches that usually in one form (*scalaris*) stop at the dorsal stripe but in another (*phenax*) crosses the back and fuses with its fellow on the opposite side, forming crossbars. As in the case of the number of preoculars, not enough is known about the factors which influence the arrangement of these spots to enable us to pin our faith to them as indicative of racial affinities; as also with the number of preoculars, however, the fusion of the spots into transverse blotches for the entire length occurs in forms which other evidence seems to indicate are closely related, so that the presence of this arrangement seems to group these forms in a natural way. Furthermore, I believe (my reasons are given on pp. 120–158) that the forms that have this arrangement of the lateral spots are directly related to those that tend to have more than a single preocular, in which case the two characters when used together serve to define a natural section of the genus.

Variation in stripes.—Ever since the establishment of the genus *Eutaenia* by Baird and Girard, the possession of three longitudinal light color bands has been considered a distinctive feature of the genus and the particularities of these stripes used as diagnostic characters. They are, as we have seen, disposed as a single dorsal and two lateral bands, the dorsal covering the median and usually more or less of the adjacent rows, when present, the laterals a varying amount of the second, third, and fourth rows on either side.

The peculiarities of the dorsal stripe that have been used in systematic work are its presence or absence and width, and these char-

acters are fairly constant in the different forms. For example, in *marcianus, ordinoides,* and *elegans* it is usually narrow, while in *radix* and *sirtalis* it is decidedly wider, and while it is present in most groups, it is almost universally absent in *hammondi, melanogaster,* and *sumichrasti.* It is thus often of considerable value in distinguishing the different forms that occupy the same region. Even in its more general aspects, however, it is unreliable as a test of affinities, as is attested by the considerable range of variation in width which it frequently exhibits in the same form. Indeed, in some instances it tends to be nearly or entirely lost in certain parts of the range of a form in which it is elsewhere distinct, so that an attempt to use it as a test of genetic relationships must result in the grouping together of widely divergent forms. The causes of these variations in the dorsal stripe are difficult to trace without a knowledge of habitats. In certain melanistic forms, such as *concinnus,* it is present, but narrow. On the other hand, in certain quite pallid types (*elegans* and *eques*) it is also quite narrow. As a rule, however, in most melanic forms it is either narrow, obscure, or absent, although it is also obsolete in at least one form in the mountains of Mexico (*sumichrasti*) which is decidedly not melanistic.

It is hardly possible to plot on a map the regions where the dorsal stripe tends to be lost, for the tendency varies with the form, while in the case of melanism the cause is apparently not always a climatic one. For example, in northeastern United States the genus tends to become decidedly darker colored. In *sirtalis* specimens this darkening of the general color is associated with the narrowing and frequent loss of the dorsal stripe, but no such tendency is exhibited by *sauritus,* which occupies the same region. Similarily, also, although *sumichrasti* on Mount Orizaba has lost its dorsal stripe, it is distinct in *scalaris* specimens from the same region. The forms of the Mexican plateau all usually show the dorsal stripe distinctly with the exception of *melanogaster,* in which it is characteristically lacking. In this form, however, it accompanies a melanistic coloration which can not be due to climate, as this is a desert region, but is possibly associated with the more aquatic habitat of this form. In this connection it is interesting to note that the dorsal stripe in *megalops,* in which the dorsal is generally very well defined, is usually very much obscured in specimens taken from Lakes Chalco and Patzcuaro, Mexico, where the form tends to be much darker, and also seems to be quite aquatic in its habits. The conclusion seems justified, therefore, that the dorsal stripe is probably modified by several factors, one of these being the general darkening of the body color. At any rate, the same peculiarities arise independently in different forms not directly related, thus invalidating these characters as indications of affinities.

As in the case of the dorsal stripe, the position of the lateral color bands has been made the basis of specific diagnoses, for it was apparently recognized quite early that the position of these stripes was constant in the different forms. Thus, Baird and Girard (1853) noted that in the ribbon-snakes its position was on the third and fourth rows, in distinction from the other forms then known, in which it was upon the second and third rows;[a] while Cope, Brown, Stejneger, and others have continued to make use of it as a distinctive character as the genus became enlarged.

The position of this stripe has been reported by Taylor (1892, 320) to be subject to occasional variations (apparently meaning here individual variation), but this conclusion may probably be taken as a result of an attempt to group specimens of apparently similar but in reality distinct forms, for there can be no doubt of the really remarkable fixity of this trait. In not a single specimen in the 3,000 that have been examined has the position of the lateral stripe varied as much as a single row from the normal for the form.[b]

There seems to be some evidence that the position of this stripe is affected by the factors that influence the dorsal, for in northeastern, northwestern, and southwestern United States, and the mountains of eastern Mexico there is a tendency toward a narrowing and loss of the lateral stripe in certain forms, that closely parallels similar conditions in the dorsal band. This is not other than is to be expected, from the fact that the stripes very probably have the same physiological significance, but, be this as it may, the extent of the modifications is so decidedly less in the case of the lateral stripe that there are but two forms (*angustirostris* and *phenax*) known at the present time in which it is characteristically absent, none in which it is on other than the second, third, and fourth rows, two (*marcianus*, *butleri*) in which it is difficult to say whether it is upon the second and third or third and fourth rows, and but one (*butleri*) of the latter in which there can be much question as to which of the two positions it is to be referred.

The position of the lateral stripe is thus apparently a very good and reliable specific character, owing to its constancy within the

[a] Baird and Girard erred in classing *radix* (the only form listed in the Catalogue of North American Reptiles besides the ribbon-snakes that has the stripe on the third and fourth rows) with those having the bands on the second and third rows.

[b] Hay (1892, b522) records a specimen of *sauritus* from Wabash County, Indiana, which had the stripe on the fourth and fifth rows. It should be noted, however, that this snake had also 21 scale rows, which is such an unusual number among the ribbon-snakes that in the large numbers examined we have never observed a specimen with over 19. It is thus very probable that the individual was abnormal as regards the arrangement of the dorsal scale rows, and the possibility is at once suggested that an extra row may have been added on either side below the lateral stripe, which would be a decided abnormality.

limits of the different forms. It may still be subject to modifications, however, that cause it to vary between the different forms. Should such changes occur they may be conceived to take place in two ways—either independently or dependently of the scale rows upon which they are situated. If they are independent of particular scale rows, changes in their position might take place either suddenly or gradually. A gradual change ought to show forms that are characterized by a different arrangement of the stripe intergrading with each other in this regard, unless, indeed, they have since become distinct. An examination of the intergrading forms, however, fails to reveal anything of this nature. Thus, *sirtalis-parietalis-concinnus, elegans-ordinoides,* and *proximus-sauritus* can be shown to intergrade along their common boundaries, and yet there is no change in the position of the lateral stripes, the intergradents being characterized by the same arrangement of these bands. Similarly, also, in the case of the forms now apparently isolated (*megalops* and *hammondi,* for example, see pp. 123 and 137) the evidence of the other characters and of geographic probability point much more strongly toward a relationship with the forms in which the lateral stripes have the same position than with others. These evidences of relationship also argue against the possibility of a sudden change in the position of the stripes as regards the scale rows, for, as far as I can see, there is no evidence of relationship between any two forms with the bands on different rows that is strong enough to require us to adopt this view for which we have no direct evidence. This apparent constancy in the position of the lateral stripes both within the different forms and between related forms gives strong support to the view that these bands are closely associated with particular scale rows.

Even if the lateral stripes are associated with certain scale rows, however, there is still the possibility that their position may be changed by the loss or addition of certain of these rows, but a moments consideration will show that the chance for any great modification in this way is slight. At present, as we have seen, the fourth is the lowest row to be dropped in the reduction in the number of scale rows. The position of the stripe when on the second and third rows can, therefore, experience no change in a decrease in the number of scale rows from 23 to 15, the range of variation in the genus, for it is only the fourth, fifth, sixth, and seventh that are lost in this reduction.

In those forms in which the stripes are upon the third and fourth there is also little chance for modification, for in but one instance is the fourth row of scales dropped anteriorly to leave 17. It is, however, in this group that most of the modifications in the position of these stripes occur, and these variations are associated

with the reduction in the number of scale rows. Thus, where the fourth row is dropped posteriorly to leave 17 the lateral stripe in one form (*radix*) is left upon the third row only, in two forms (*butleri* and *megalops*) it descends below the third to include the second, while in three forms (*proximus*, *sauritus*, and *sackeni*) it ascends one row after the loss of the fourth, so as to remain posteriorly also upon the third and fourth. In but two forms is the position of the stripes modified anteriorly, and in one of these (*marcianus*) it is apparently due to the general pallidness of the ground color which partially obscures it; in the other (*butleri*) we have the only decidedly dwarfed representative of the forms which have the stripe upon the third and fourth rows. When the scale formula in *butleri* is 19–17, the lateral stripe is anteriorly upon the third and the margins of the second and fourth rows, posteriorly upon the second and third. When the scale formula is decreased to 17–19–17, the lateral bands are anteriorly and posteriorly upon the second and third rows, on the middle of the body being still upon the second, third, and fourth. In the forms that have the lateral stripes upon the third and fourth rows there is thus apparently exhibited a tendency toward producing a form with the stripe upon the second and third rows, but as this only takes place in the most dwarfed forms and is evidently due to dwarfing it can in no way be taken as lessening the gap between the groups that have it upon the second and third, and those in which it is upon the third and fourth, for it would be absurd to maintain that the former were dwarfed descendants of the latter, since they are by no means all dwarfed forms.

I have shown that the other traits (number of scales, color, and tail length) are subject to modifying influences, and although of assistance are not to be depended upon as indicating related groups. If, however, I have succeded in establishing that the position of the lateral stripe is not affected by the various influences that divide the genus into many and diverse forms, I should find in it a trait that will when availiable give us a true idea of the general relationships of the different forms.[a]

Variation in color.—There is considerable variation in the specimens examined, but this is so largely individual that it is difficult to define a normal color for a form, and, even when there are well marked geographic differences among the forms, those in the same

[a] Coues and Yarrow (1878, p. 273) were apparently the first to point out the significance of the position of the lateral stripe, although they did not pretend that the members of the different groups were genetically related. The following is their statement of the case: "As far as we have seen, the position of the lateral stripe may be a means of grouping the species. Though this varies within certain limits, mainly according to the width of the band, yet its position on the third and fourth, or on the second and third, dorsal rows affords a ready means of distinguishing certain sets of species or varieties." The validity of this statement has been questioned by Taylor (1892, 320), but, as indicated above, his criticism was probably not well founded.

region tend to be similarly colored, as Allen has pointed out a number of times in mammals and birds, so that it is impossible to distinguish them sharply on this basis. The following unquestionable tendencies may be noted:

1. A marked increase in bright colors in the Pacific coast region in Washington, and Oregon, and British Columbia. This is shown by the presence of bright reds and greens (*concinnus, ordinoides*).

2. An increase in the amount of black pigment at the expense of the paler colors in the region just mentioned. This is especially shown in the enlargement of the lateral spots to the obliteration of the interspaces on the skin and a narrowing of the dorsal stripe (*concinnus, ordinoides*).

3. A tendency toward a paler ground color and lighter stripes in the forms inhabiting western Texas, southern New Mexico, southern Arizona, and northern Mexico (*marcianus, eques*).

4. A tendency toward the production of red pigment on the Great Plains (*parietalis* and occasionally *radix*).

5. A tendency toward dark colors in the forest region of eastern United States. This is shown by the prevailing brown ground color in *sauritus* and *butleri*, and the dark greenish and brownish olives in *sirtalis*.

An increased darkness of color thus occurs in the more humid areas, while the paler colors are usually found in the more arid regions; some well marked exceptions occur, however. Thus, in the arid region of northern Mexico *angustirostris* and *melanogaster*, which are very dark in color, occur with the paler *megalops* and *eques*, and in central Texas *proximus* is much darker than *marcianus*. More detailed notes on these forms are needed before much can be done by way of explanation, but it is significant that the dark forms (*melanogaster, angustirostris*, and *proximus*) mentioned above as occurring with pale ones in an arid region are known to be more than usually aquatic in habits. We believe that it will be found that the color in these snakes is not, as in mammals and birds, closely correlated with the major environmental complexes, owing to the fact that they prefer damp situations, and are thus not exposed to the same conditions throughout their range as terrestrial mammals and birds. At any rate, owing to the great variability, color is one of the least important characters that have been used in diagnoses.

As is well known, the characters that have been discussed are by no means all that have been used by students of the group to define species. They are, however, those which we have found to be of the most importance. The number of temporals and comparative length of fore and hind chin shields, while both of use in defining certain species, are too variable or the peculiarities of too limited occurrence to permit of their use in a search for general relationships. The

shape of the frontal (i. e., length in relation to width) is also useless as a diagnostic character, owing to its variability; while, as shown above, the position of the eye relative to the supralabials (i. e., the particular labials which enter the orbit) is dependent upon the number of labials in this series.

THE FOUR GROUPS OF GARTER-SNAKES.

It may seem the extreme of "lumping," in view of the thirty forms[a] that are at present recognized by herpetologists, to assert that there are but four great groups or lines of descent in the garter-snakes, but I believe that the evidence is sufficient to warrant the assertion. The first step in the division of the genus into genetic groups is to determine the different associations of traits, or forms, that exist at the present time. This has of course already been largely accomplished in the definition of the species and varieties that have been made, and it remains for us now to assemble these forms into the general groups.[b]

The table that follows expresses all of the different combinations of characters that are shown by these snakes at the present time, and it will be seen that there are nineteen of these combinations or forms recognized. These comprise all of the different forms of garter-snakes that have a geographic range, and disposes of the multitude of forms that have been described upon the basis of individual or sexual variations.

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[a] This number has been attained by adding the better defined Mexican and Central American forms to the North American forms admitted by Brown (1901) in his "Review of the Genera and Species of American Snakes North of Mexico" (a conservative estimate).

[b] It is best at the outstart to ignore all questions of species and subspecies until their status is established, and to speak of these as forms. Forms, therefore, in the sense employed in this paper, are actual combinations of traits, having geographic extent, irrespective of whether they are isolated (species) or intergrade with their neighbors (subspecies). Detailed discussions of questions of nomenclature are also omitted, although the names used are in every case the ones that, in the light of the development of these investigations, we judge to be the right ones, following the International Code of Zoological Nomenclature. The proper name of each form will be found in the footnotes, together with the synonymy.

Table to illustrate the combination of traits into forms, groups, and divisions in the garter-snakes.

Position of lateral stripe.	Preoculars and arrangement of lateral spots.	Proportionate length of tail.	Number of dorsal scale rows.	Number of supralabial scutes.	Forms.	Groups.	Primary divisions.	Genus.
On the third and fourth rows.	Preoculars one and lateral spots not arranged as cross-bars.	Generally less than 27 per cent.	21-23-21-19-17 21-19-17 19-21-19-17 19-17	(9)-8	*megalops*	*Radix*	I	THAMNOPHIS
			21-19-17	8	*marcianus*			
			21-19-17 19-21-19-17* 19-17 17-19-17	8-7	*radix*			
			19-17 17-19-17-15	7-6	*butleri*			
		Generally more than 27 per cent.	19-17 17-19-17	8-(7)	*proximus*	*Sauritus*		
			19-17	8-(7)	*sackeni*			
				(8)-7	*sauritus*			
			21-23-21-19-17 21-19-17 19-21-19-17	(9)-8	*angustirostris*			
			21-19-17 19-21-19-17		*hammondi*			

On the second and third rows.	Preoculars two, or lateral spots arranged as cross-bars, in some part of the range.	Generally less than 27 per cent.	21-19-17 19-21-19-17 19-17	8–(7)	*elegans*	*Elegans*	II	THAMNOPHIS
			19-21-19-17 19-17 17-19-17-15 17-15 15-17-15	8–7–6	*ordinoides*			
			19-17	8	*melanogaster*			
				8–7	*phenax*			
			19-21-19-17 19-17 17-19-17-15 17-15	(8)–7	*scalaris*			
	Preoculars one and lateral spots not arranged as cross-bars.	Generally less than 27 per cent.	19-17 17-19-17-15	8–7	*eques*	*Sirtalis*		
			19-17	(8)–7	*sirtalis*			
					parietalis			
					concinnus			
			19-17-15 17-19-17 17-15	8	*sumichrasti*			

In the discussion of the value of the characters an attempt was made to show that the position of the lateral stripe groups related forms, and that the proportionate tail-length, and the number of preoculars and presence or absence of lateral cross-bars,[a] are also of value in this regard, if used within the limits of the groups having the lateral stripe in the same position. If we have made our point, then, the nineteen forms defined in this table fall naturally into four groups, the members of which should be genetically related.

To each of these four groups of garter-snakes we have for convenience given the name of the best known form which it includes. Thus we have the *Radix* group with the lateral stripe upon the third and fourth scale rows and a short tail; the *Sauritus* group with the lateral stripe on the third and fourth rows and with a long tail; the *Elegans* group with the lateral stripe upon the second and third rows, and with either more than one preocular scute in some part of the range or the lateral spots arranged as cross-bars in some part of the range, and the *Sirtalis* group with the lateral stripe on the second and third rows, and never more than a single preocular, or lateral cross-bars.

It will probably be conceded at once that the ribbon-snake group (*Sauritus*) is a natural one, and there can be little question that the forms included in the *Radix* group are also related, although the placing of *marcianus* with these snakes will be seriously questioned by some herpetologists. In the case of the other groups, *Elegans* and *Sirtalis*, the affinities are in many cases much less obvious, but it can not be denied that as thus defined the groups include those forms which are evidently related. Thus there is no question but that *hammondi*, *ordinoides*, and *elegans*, which are here placed in the *Elegans* group, are closely related, nor that *sirtalis*, *parietalis*, and *concinnus*, in the *Sirtalis* group, actually intergrade. The evidence for the inclusion of the other forms in these groups, as well as further proof that the above-mentioned forms are properly placed together, will be given in more detail when the forms are discussed separately, and the lines of interrelationship considered.

The continuous geographic range of the four groups also seems to strengthen the evidence of the characters that they are associations of directly related forms. As is shown on the maps, the *Radix* group occurs on the Mexican plateau, great plains, and in the prairie region; *Sauritus* is a coastal plains group, extending from British Honduras to Maine, only penetrating into the interior in the forests of eastern United States and along the streams of the great plains; the *Elegans* group occupies the Mexican plateau and, in the United States, all of

[a] It has been a source of regret to the writer that a single trait could not be found to separate the *Elegans* and *Sirtalis* groups. Most students of snakes have encountered a similar difficulty, however, for the different groups of snakes, apparently owing to the recency of the order, are frequently not sharply defined by any single difference that is obvious.

the region west of the Rocky Mountains, only occurring east of these mountains on the high plateaus; the *Sirtalis* group occupies the plateau region in Guatemala and Mexico, and in addition practically all of the United States and southern Canada, from the Atlantic to the Pacific. The range of each of these groups, as will be shown later, is made up of the ranges of the component forms placed side by side.

The evidence seems to be quite conclusive, therefore, that these groups are assemblages of directly related forms, and it is necessary now to consider in detail the forms comprising these groups in order to determine the directions of their relationships. If this detailed examination bears out the evidence that the groups are genetic, and reveals the direction of the affinities within the groups, much light should be thrown upon the origin and history of these snakes.

A key is given by which the forms may be recognized.

Key to the forms of the genus Thamnophis.

a^1. Lateral stripe anteriorly upon the third and fourth rows.
  b^1. Tail generally more than .27 of the total length.
    c^1. Supralabials usually 8.
      d^1. Tail between .25 and .35 of the total length ..... *proximus*, p. 98.
        (Illinois to western Nebraska, southward in eastern Mexico to Central America.)
      d^2. Tail between .32 and .38 of the total length ..... *sackeni*, p. 107.
        (Principally confined to Florida.)
    c^2. Supralabials usually 7 ..... *sauritus*, p. 112.
      (United States east of the 87th parallel, and north of Florida.)
  b^2. Tail generally less than .27 of the total length.
    c^1. Dorsal scale rows usually 21–19–17, supralabials 8, occasionally 9 ..... *megalops*, p. 44.
      (Southern Arizona and New Mexico, the plateau of Mexico.)
    c^2. Dorsal scale rows usually 19–21–19–17, supralabials 7 or 8 ..... *radix*, p. 70.
      (Great plains and prairie regions of central North America.)
    c^3. Dorsal scale rows usually 19–17, supralabials 6 or 7. ..... *butleri*, p. 87.
      (Indiana, Ohio, southern Michigan, western Pennsylvania.)
a^2. Lateral stripe anteriorly upon the third row only ..... *marcianus*, p. 58.
  (Central Texas, southern New Mexico and Arizona, northern Mexico.)
a^3. Lateral stripe upon the second and third rows.
  b^1. Dorsal scale rows usually 21–19–17 or 19–21–19–17.
    c^1. Dorsal stripe usually absent.
      d^1. Eye in contact with two supralabials ..... *hammondi*, p. 133.
        (Southern California and northern Lower California.)
      d^2. Eye in contact with a single supralabial ..... *angustirostris*, p. 120.
        (Northern part of the Mexican plateau, southern New Mexico and Arizona.)
    c^2. Dorsal stripe usually present ..... *elegans*, p. 138.
      (From the Rocky Mountains to the Sierra Nevada-Cascade Range, inclusive.)
  b^2. Dorsal scale rows usually 19–17 or less.
    c^1. Dorsal stripe usually present.
      d^1. Never more than 1 preocular.
        e^1. Supralabials usually 8 ..... *eques*, p. 158.
          (Guatemala to southern Arizona and New Mexico on the plateaus.)
        e^2. Supralabials usually 7.

f^1. Lateral spots fused into transverse blotches for the entire length.. *scalaris*, p. 127.
(Southern Mexico and northern Central America.)
f^2. Lateral spots not fused into transverse blotches for the entire length.
g^1. Both rows of lateral spots distinct on the skin; interspaces not generally red ..... *sirtalis*, p. 176.
(North America east of 91st meridian and south of the 52nd parallel.)
g^2. Upper row of lateral spots usually fused on the skin; interspaces red.
h^1. Dorsal stripe usually covering one and two half-rows. Width of interspaces on skin equal to the length of one scale ..... *parietalis*, p. 166.
(From the 91st meridian to the Pacific coast, exclusive of western Oregon and Washington, and south of the 52nd parallel.)
h^2 Dorsal stripe usually confined to one row. Width of interspaces on skin generally less than the length of one scale, frequently absent..... *concinnus*, p. 173.
(Western Oregon and Washington.)
d^2 Frequently 2 preoculars..... *ordinoides*, p. 147.
(California, Oregon, and Washington, west of the Sierra Nevada-Cascade Range.)
c^2 Dorsal stripe usually absent.
d^1 Dorsal scale rows 19–17.
e^1 Lateral spots fused into transverse bars, which usually extend entirely across the back..... *phenax*, p. 130.
(Veracruz, Mexico.)
e^2 Lateral spots not fused into transverse bars ..... *melanogaster*, p. 124.
(Southern Mexico.)
d^2 Dorsal scale rows usually 17–19–17 or 17–15..... *sumichrasti*, p. 164.
(Southern Mexico.)

THE RADIX GROUP (MEGALOPS, MARCIANUS, RADIX, AND BUTLERI).

MEGALOPS.[a]

Description.—The Mexican plateau, possibly on account of its topographic unity, is the home of one of the most homogeneous forms in the genus, notwithstanding the fact that this form has been divided into four species (*megalops* and *macrostemma* Kennicott, and *flavilabris* and *insigniarum* Cope). This form, if we succeed in establishing its unity, should be known as *megalops*, and is undoubtedly the largest of the garter-snakes. It is characterized in general by having the lateral stripe on the third and fourth rows, mostly 21–19–17 scale rows, 8 or 9 supralabials, 152 to 174 ventrals, 60 to 87 subcaudals, and a proportionate tail-length of .20 to .278. There is considerable variation in color, so that no single description can be given that will apply for the form. For detailed description see page 55.

Habits and habitat relations.—As is usually the case among reptiles, but little has been recorded concerning the habits of *megalops*, which

[a] *Thamnophis megalops* (Kennicott), Proc. Acad. Nat. Sci. Phila., 1860, p. 330. Includes *E. macrostemma* Kennicott, *E. insigniarum* Cope, and *E. flavilabris* Cope.

is unfortunate, as a knowledge of its habitat would undoubtedly throw much light upon the explanation of its distribution. At first sight it seems rather surprising that a species of this genus should occur so abundantly in an arid region, and three alternative explanations present themselves. It may be either a distinctive desert type and confined to arid localities even in the more humid (southern) portions of its range, or it may, on the other hand, be addicted to a more aquatic habitat, being confined in the desert regions to the vicinity of water. As a third alternative it may be that the form is able to adjust itself to either arid or moist conditions, a change that if extensive might necessitate a change of habits.

The second explanation is probably most nearly the true one, for the genus is notably inclined toward a moist habitat. Cope in 1885 (1885a, 386–387), writing of the habits of this snake at Lake Xochimilco, near the City of Mexico, says, "The ends and shores of the piers are the resting places of innumerable water snakes, which can readily be observed from a canoe. * * * We caught a considerable number and found that they belong to the two species above named [*insigniarum* and *melanogaster*]. The *E. insigniarum* is the most active, sooner seeking the water, where it swims, keeping close to the shore, and remaining more or less in sight until it conceals itself in a hole. * * * The food of both of these species is the *Rana montezuma* Baird and another species allied to *Rana halecina*."

Again (1900, 1030) he writes: "On being disturbed the *E. macrostemma* plunges into the water, but does not go far beneath the surface, but takes refuge under the edge of a bank, or emerges in a new spot, so that it is difficult of capture. The columns that support the aqueduct that carries water from Chapultepec to the City of Mexico are covered with a dense vegetation, which is continuously watered by leaks in the venerable structure. On examining this vegetation at my height above the ground, I encountered in the thick of it a round eye. Exposure revealed first the head and then the body of a snake of this species, which found a congenial abode there."

Baker in 1895 (1895, 120–121), in speaking of a trip on Lake Patzcuaro says, "As we approached the island, a commotion was observed in the water, and a snake was seen to glide swiftly and noiselessly away. I quickly shot it; on picking it up we found it to be a large species of water snake (*E. insigniarum*). As we pushed our boat among the reeds bordering the island a great commotion was created in the water and a number of these snakes were seen to swim away."

From these accounts and the large numbers of specimens in different museums from the lakes of southern Mexico, there can be no doubt that *megalops* in southern Mexico not only thrives in a moist locality but is also quite aquatic in its habits. In contrast with these descrip-

tions is that of Doctor Coues (1875, 613), who states that according to his observations the species in Arizona is not "specially addicted to the water, frequenting dry herbage and bushes." This statement may justly be withheld as evidence, however, for, as will be shown later, the identity of the species which Coues referred to is doubtful. Since Cope's Duck Creek, New Mexico, specimen was also found in swampy ground in the vicinity of water, we may conclude that as far as our present knowledge goes *megalops* throughout its range prefers the vicinity of water. If this is true, while of more general distribution in the southern parts of its range (States of Mexico, Puebla, etc.), to the northward it probably becomes confined to those habitats in which water is to be found for the greater part of the year.

Range.—Much of the unity of this form may be accounted for by the character of the region which it inhabits. Geographically the Mexican plateau is a tableland lying at an elevation of 3,000 to 8,000 feet, and separated from the Gulf of Mexico on the east, and the Gulf of California and the Pacific Ocean on the west, by parallel mountain chains and a narrow strip of coastal plain. To the north it descends gently into the open basins of southern Arizona and southwestern New Mexico, being limited in its northward extension by the escarpment of the Colorado plateau, thus including the Proplateau region of southern United States (see Ruthven, 1907). Southward it extends to the isthmus of Tehauntepec, where it ends by the junction of the two parietal mountain ranges. This plateau has been built of the accumulated waste of the preexisting mountains, and volcanic discharges, the existing mountain peaks protruding through this mass, mainly in the higher parts of the plateau, as nunataks in an ice field (Heilprin, 1902, 774–775).

The climate of the plateau may be characterized in general as temperate (Heilprin, 1900, 777). The amount of precipitation is variable. In southern Mexico it is comparatively great, the rainy season lasting about six months, and the streams and lakes are perpetual. To the northward, however, owing to the influence of the eastern chain of the Sierra Madres, much of the moisture carried by the warm gulf winds is precipitated on the coastal plain, so that in their subsequent passage over the tableland they are desiccating winds. During the short rainy season of three months the flora of this arid region grows luxuriantly, but during the long dry season, in which the region is exposed to the glare of the tropical sun and the hot, dry winds, the vegetation becomes parched, and the streams and lakes partially or entirely dry. The aridity of this area increases to the northward, from San Luis Potosi northward being known as the Chihuahuan desert that grades into the Proplateau region of southwestern United States. This entire region, therefore (northern part of the Mexican plateau and the Proplateau regions), is arid. The

plains and lower mountain slopes are the home of the cactus, mesquite, yucca, creosote bush, and prickly pear, while the summits and canyons support a luxuriant growth of hardwoods or pines, according to the altitude.

Specimens have been examined from Tucson and Yuma, Arizona; Duck Creek, New Mexico; Lerdo, Durango and Coyotes, Durango; Guanajuato; Ocatlan, Jalisco; Lake Chalco, Chapultepec, City of Mexico, Chalco, Lake Xochilmilco, and Lerma, Mexico; Patzcuaro, Michoacan; Puebla, Puebla; "South Mountain or Micrado," Veracruz; Colonia Juarez, Jimenez, Chihuahua, San Andreas, and Minaco, Chihuahua. From these records the range of *megalops* may apparently be defined as the entire southern part of the Mexican plateau, extending northward along the western part of the plateau into southern Arizona and New Mexico. Owing to the fact that no real boundary of the tableland exists on the north, no geographical line of demarcation can be drawn here, and we find the species ranging into the open basins of southern Arizona and southwestern New Mexico, as far west as Yuma and to the north possibly to the escarpment of the Colorado plateau (the northernmost records being Fort Whipple, Arizona, and Duck Creek, New Mexico). Coues (1875, 615) recorded the species from Fort Whipple, Arizona, and Cope determined his specimens as this form. We are unable either to find these specimens or any others from this locality, so that, in view of the difficulty that has existed in properly distinguishing the garter-snakes of the southwest, this record should be held in abeyance until supported or denied by further evidence. Whether or not the form extends entirely across the northern part of the Mexican plateau, i. e., into the States of Coahuila and San Luis Potosi, remains to be discovered.

As we stated in the consideration of the environmental conditions, there are no geographic barriers in an east and west direction on the plateau, and *megalops* probably ranges over the entire area (Fig. 13).

Variation.—The uniformity of topography is clearly expressed in the homogeneity of scutellation, and the variation when properly determined elucidates many of the questions that have arisen over the division of the form. Bearing in mind that the males have as a rule a longer tail and more ventral and subcaudal plates than the females, and making allowance for the irregularities caused by a marked dominance of either in the averages, it will become evident that a great similarity in scutellation prevails all over the plateau from Puebla to Arizona. The scale rows, only in rare instances, vary from 21–19–17 by the presence or absence of a row; the ventrals vary from 152–173 with an average of about 160–165; the tail length is about .23 of the total length in the males and .21 in the females, and the number of labials oscillates about an average of 8 or 8.5. So

closely is this unity preserved over the entire extent of the range that it is only by carefully plotting the data from large series that any definite trend in the variations can be observed. When this is done, however, there is seen to be a distinct although slight decrease in scutellation and tail length toward the south.

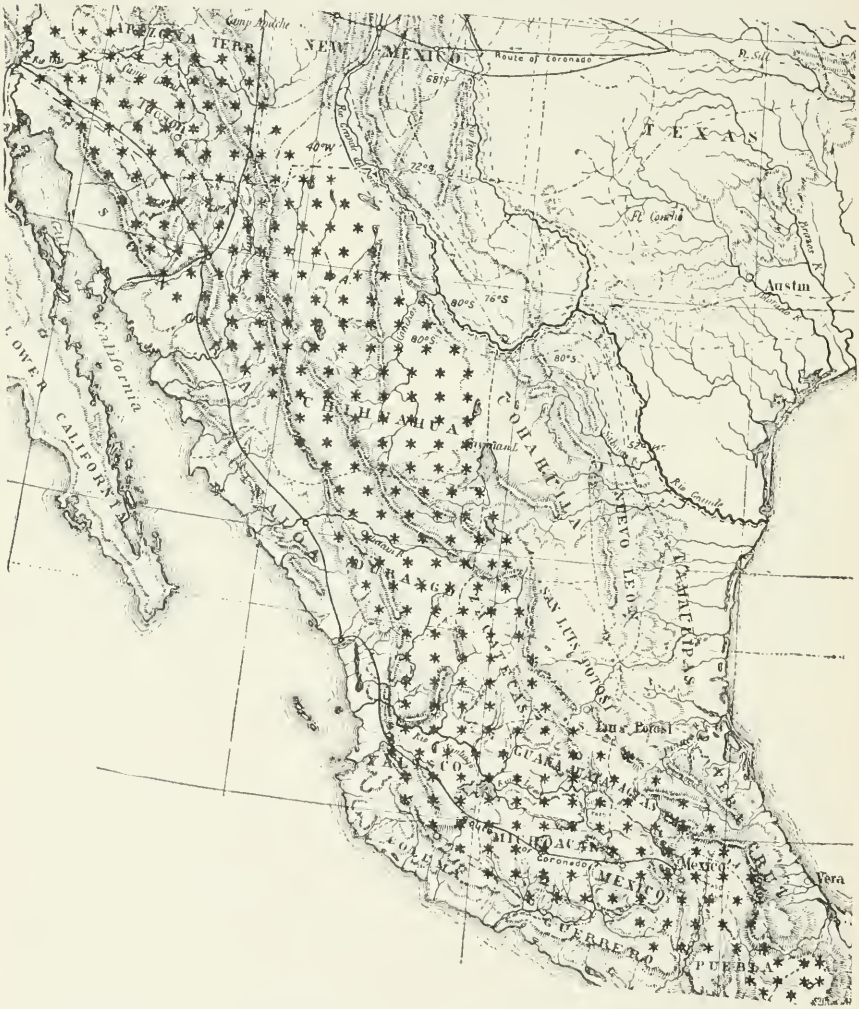

FIG. 13.—DISTRIBUTION OF THAMNOPHIS MEGALOPS, AS INDICATED BY THE LOCALITY RECORDS.

From Arizona to Patzcuaro, Michoacan, no specimen has been examined with less than 21–19–17 scale rows, but 6 out of 45 specimens from the intervening region exhibit a tendency to have more than this number, in the presence of an extra row on either side for a varying distance, thus making the formula 21–23–21–19–17, the extra row never extending to the head. South of this locality but

one specimen has been examined with more than 21–19–17 rows, while about the City of Mexico and in Puebla a considerable proportion have the reduced formula of 19–21–19–17, and in three specimens from Veracruz one has 21–19–17, one 19–21–19–17, and the third 19–17, the smallest number for the species. It is also of interest to note here that the type of *flavilabris* which was from Veracruz (State) was said to have had 19 scale rows (Cope, 1866, 306). In the diagram that constitutes fig. 14 we have attempted to represent graphically this geographical variation in the number of scale rows.

The number of specimens at our disposal may perhaps seem too small upon which to base conclusions as to the variations in the number of scale rows, since it has often been affirmed that the number may vary a row or two in the same locality. Bearing in mind, however, the narrow limits of individual variation shown in our locality

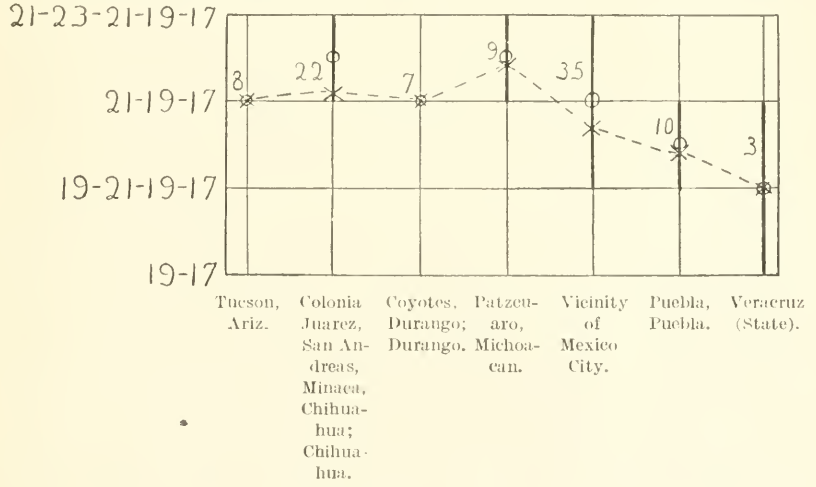

FIG. 14.—DIAGRAM SHOWING THE VARIATION IN THE DORSAL SCALE FORMULA IN THAMNOPHIS MEGALOPS.

records and indicated on our diagram, it may be clearly seen, even from this limited series, that, although slight, the decrease in the number of rows from Patzcuaro southward is entirely definite; while a similar reduction is indicated to the northward that may or may not be confirmed by larger series.

In the number of labials, as in the case of the dorsal rows, the question of sex may be ignored and the averages plotted directly, as has been done on the diagram, fig. 15. By comparing the tables it will be seen that although the arithmetical mean is quite constant, it is not uncommon to find 9 supralabials and 10 infralabials in Chihuahua; that no specimen north of Patzcuaro has been observed with less than 8, and that south of this locality 9 labials very seldom

occur. This variation is so slight that were it not for the considerable number of specimens upon which the averages have been based it might almost be ignored. However, it indicates, we believe, that there is a geographical variation in these plates, correlated with the decrease in the number of scale rows to the southward in Mexico. As

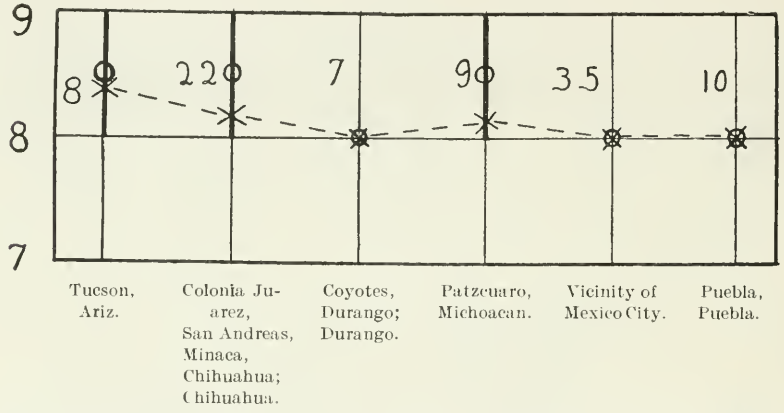

FIG. 15.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS MEGALOPS.

we have before stated, the number of infralabial plates is more subject to individual variation and requires a larger series than is here available to furnish the mean number for each locality. Fig. 16 will show the amount of variation in the material examined.

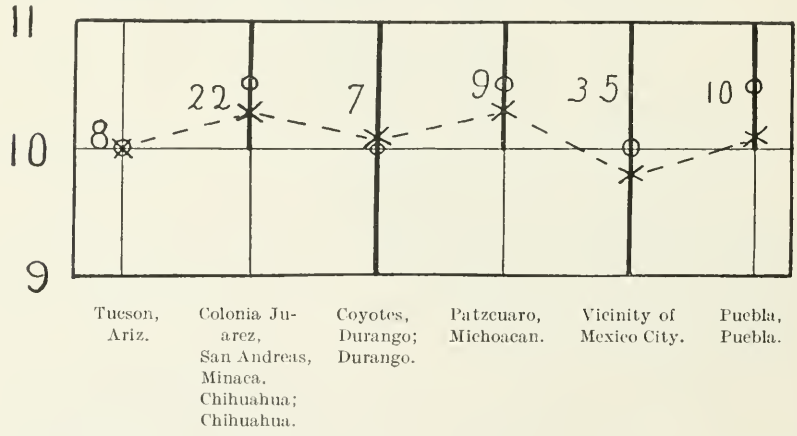

FIG. 16.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF INFRALABIALS IN THAMNOPHIS MEGALOPS.

In regard to the ventral scutes a similar variation is to be observed, but, as indicated above, the question of the sex of the specimens examined must be carefully noted. In general it may be said that there are in the males from 0 to 17 more plates than in the females,

so that if one sex greatly predominates in a locality it may throw the average either above or below that of another locality in which the opposite sex prevails, and thus obscure any geographical variation that may exist unless very pronounced. Even when each sex is plotted by itself geographical variation may be obscured by the individual variation owing to the small number of specimens. If, however, it can be shown that there is a similar geographic variation in both sexes and this cause of fluctuation is removed by combining the two sexes in approximately equal proportions, the increased amount of material should reduce the individual variation and also tend to decrease both the sexual and individual variations below the geographic.

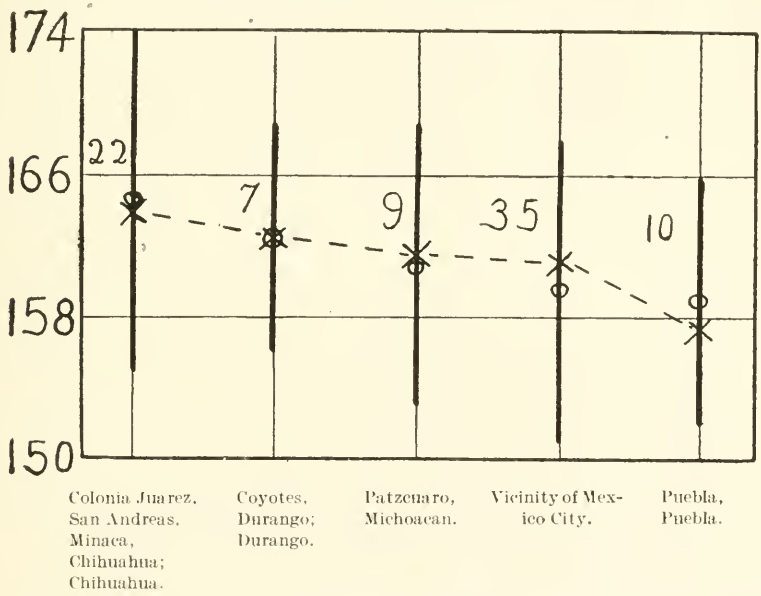

FIG. 17.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF VENTRAL SCUTES IN THAMNOPHIS MEGALOPS.

When the range of variation in the two sexes is examined separately it is found that in Chihuahua the average number of gastrosteges in the males is 170 and in the females 165, a condition that seems to prevail southward nearly to Patzcuaro; at the City of Mexico, however, it is 165 in the males and 160 in the females, which indicates a reduction in gastrosteges in both sexes very similar to that of the scale rows. In diagram, fig. 17, I have plotted the locality variations in the number of these plates, and, although the sexes are only approximately equally represented in each series, I believe that the mean represents nearly the average number for each locality. If I am right in this it will be seen that there is a gradual decrease in the number of ventrals from Chihuahua and Patzcuaro toward Mexico City and

Puebla. While a similar reduction is indicated in my material from southern Arizona, the series upon which the computations are based is too small to be relied upon as representative.

The variation in the number of subcaudal plates is very similar to that of the ventral plates, but, owing to the much wider range of both sexual and individual variations, the geographic is even more liable to be obscured. In general the males may be said to have from none to about 10 urosteges more than the females, while the individual variation in the males may be as high as 12 and in the females 8.

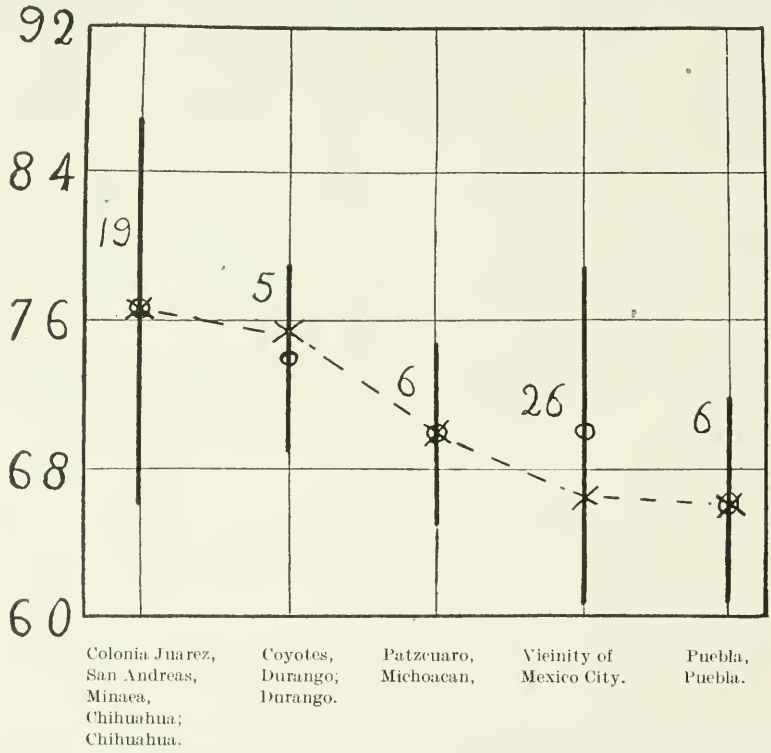

FIG. 18. DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUBCAUDAL SCUTES IN THAMNOPHIS MEGALOPS.

If we take only those localities from which seven or more specimens have been examined and examine the range of variation in the two sexes, there is shown that in Chihuahua and Durango the variation is from 75 to 87 (males) and 66 to 74 (females), while at the City of Mexico and Puebla it is 67 to 79 (males) and 61 to 67 (females), thus seeming to reveal a slight geographic variation. If males and females be combined in approximately equal numbers (fig. 18), an average of 76.3 is given for Chihuahua and 66.6 for Mexico City, which shows a slight decrease in harmony with the reduction in

scutellation, observed in the case of the scale rows, labials, and gastrosteges.

To summarize, then, there is exhibited in this form a decided tendency toward a decrease in the number of scale rows toward the southern part of the Mexican plateau, which is correlated with an apparent decrease in the number of labial, ventral, and subcaudal plates, and the locality records suggest that a similar reduction in the number of scale rows and ventrals exist in southern Arizona. In general I think that it can be safely affirmed that this reduction in scutellation to the southward is an evidence of dwarfing in this form, although it is impossible to prove it, of course, by measurements.

The proportionate tail length of specimens from the various localities has been examined and seems to be quite constant throughout the entire province, although an apparent geographic variation in this trait seems to be demonstrable. In Chihuahua it varies from .24 to .27 of the total length in the males, and in the females from .20 to .23, while about the cities of Mexico and Puebla it drops

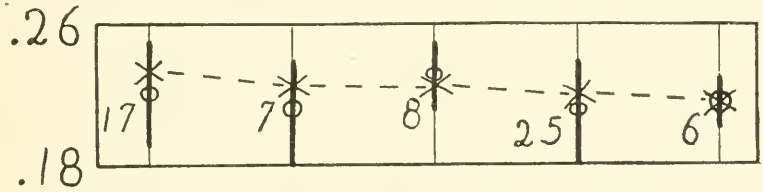

FIG. 19.—DIAGRAM SHOWING THE VARIATION IN THE PROPORTIONATE TAIL LENGTH IN THAMNOPHIS MEGALOPS.

to .20 to .22 (females) and .21 to .24 (males). When these are averaged in equal numbers and plotted (fig. 19), a slight decrease in the average length of the tail to the southward is evident. It is true that this reduction only amounts to .03, but it must be noted that the sexual and the individual variations have been excluded in large part, while a reduction approximately equal to the extremes of variation in either sex in one locality is still indicated. This decrease in the length of tail should not be confused with the decrease in the number of dorsal rows, labials, or gastrosteges, of which it is entirely independent, but it possibly explains in part the reduction in the number of subcaudals.

When the scutellation and tail length is plotted, the value of the divisions that have been made of the group on the basis of these characters is at once revealed. In 1860 Kennicott (1860, 330) described a specimen labeled "Tucson and Santa Magde" (No. 965, U.S.N.M.), collected by Major Emory and A. Schott, which had a

proportionate tail length of .25, giving it the name of *megalops*. Immediately following this he described a specimen from the City of Mexico, by Major Rich, giving no measurements, probably owing to the fact that the tail was broken. In 1885 Professor Cope (1885b, 173), in giving a synopsis of these forms, listed as *megalops* a specimen collected by himself on Duck Creek, New Mexico, which had a tail length of .26, and stated that *macrostemma* (*insigniarum*) may be distinguished by its shorter tail. In 1886 Cope (1886, 285) again listed as *megalops* ten specimens collected by Wilkinson at Chihuahua and stated that they did not differ from the Duck Creek specimen. In 1892 (1892, 646), in a key to the species of garter-snakes, he gives as the distinguishing differences that *megalops* has a tail length of less than one-third and more than one-fourth the total length, while in *macrostemma* it is more than one-fourth and not less than one-fifth, and on a subsequent page (651) lists three specimens of *macrostemma* (*insigniarum*) said to be from near Prescott, Arizona, thus extending the range of the latter to cover most of the region occupied by the former.

In 1901 Brown (1901, 22), in endeavoring to straighten out the American representatives of the group, found in five specimens from Mexico "the tail to be about one-fourth of the length, or longer than in most adult *megalops*, which reverses the proportions given by Cope." This threw the Arizona (*insigniarum*) specimens of Cope, which as Brown shows are from Tucson instead of Prescott, with *megalops*, which now becomes distinguished from *macrostemma* by the presence of a *shorter* tail; *macrostemma* is excluded from the United States, being replaced by *megalops* in southern New Mexico and Arizona.

The solution of this tangle is not hard to find if we take into consideration the sex of the specimens. In the first place, both Kennicott's type of *megalops* and Cope's Duck Creek specimens are males, the latter having a slightly longer tail than is usual, while the type of *macrostemma* (although not measured), and a number of other specimens from southern Mexico examined by Cope were females, while at least some of those that he measured (type of *insigniarum*) from the latter region, although males, have short tails, owing to the shortening that we have shown to take place toward the southern part of the range. Finally, Brown's Tucson specimens were females with characteristically short tails, which led him to reverse Cope's description.

As a matter of fact there is, as shown by our diagrams, a slight decrease in the tail length of the tail to the southward. But the amount is entirely too small upon which to distinguish a variety, much less a species, and the same thing holds true in regard to the scutellation. I have also stated that while a decrease in the scutellation in the southern parts of New Mexico and Arizona is

suggested, the tendency, if it exists, is not at all well defined. As regards the number of subcaudals and tail length in Arizona, the number of available specimens is far too small to settle this point, although the maximum number of subcaudal plates in the males is 86, while the tail length remains the same as in the Chihuahuan specimens. As regards the number of ventral scutes there is an apparent reduction, since the maximum number, even in the males, is but 165, while the minimum exhibited by the females is 153. It is to be observed, however, that although chiefly male records of the number of urosteges are to be had, this is due to the fact that it is the tails of the females in this lot that are mostly injured, and that the females actually predominate in the records, which explains the low number of ventrals. In respect to the labials the average at Tucson is 8.3, which is practically the same as in Chihuahua. The similarity in scutellation and tail length between Arizona and Chihuahua specimens is thus very close, and there is no reason to believe that a larger number of specimens will materially disturb it, so that it is impossible to divide the group here on this basis.

One more trait of the Mexican *megalops* remains for us to examine. Nearly the same difficulties have arisen over the attempt to distinguish different forms within this species on the basis of color as we have seen above to have arisen in the attempt to divide it on the basis of tail length. As is well established by the specimens, there is a considerable range of variation in color, but it remains to be seen whether this is individual, sexual, or geographic. In general the color may be defined as some shade of olive or brown, with three light stripes distinct or obscure. The lateral is on the third and fourth rows, anteriorly, posteriorly on the third only, on the second and third, or indistinct. The dorsal stripe covers a varying distance of from 1 to 3 scale rows on either side of the median dorsal one. The lateral spots are obscured on the scales in the dark specimens, but are distinct in the lighter ones, and when present occur on all but the keels of the involved scales. Of the variations of this general type four color phases may be noted:

First. The ground color is dull brownish olive, with the lateral spots visible on the edges of the involved scales, but not prominent, owing to the dark color. The lateral stripe is greenish olive, the dorsal stripe dull greenish yellow on the median and one-half of the adjacent rows, the edges not being well defined. The supralabials are dark greenish yellow, narrowly margined with black; the head olive brown and the parietal spots very small. The belly is bluish green, clouded with yellow anteriorly; the chin and throat also being yellow. (1279, Field Museum.)

Second. The ground color of the above type may become so dark as to appear nearly black, entirely obscuring the spots on the scales,

The lateral stripe is then dark and nearly obscured, the dorsal stripe represented only by dark yellow keels on the median rows of scales, the head black, parietal spots lacking, labials very dark brown, belly dark bluish, chin and throat yellow, and the supralabials brownish. (1097, Field Museum.)

Third. The ground color is dark yellow, the black spots on the skin also conspicuous on the scales, and covering all but the keels of those involved. The stripes are only indicated by the fact that the spots do not encroach as much upon the scales of certain rows. The dorsal stripe is wide, covering from three to five rows. The head is brownish yellow, parietal spots very small, labials dark yellow and narrowly margined with black, the belly, chin, and throat bright creamy yellow. (1098, Field Museum.)

Fourth. The ground color is light brownish olive; the lateral spots occur only on the edges of the scales, and the stripes are bright yellow and very distinct. The head is light brown, the parietal spots small, and the labials bright yellow, as are also the pre- and postoculars, and a postoral crescent. Distinct nuchal blotches. The belly is greenish yellow, and the chin and throat bright yellow. (1320, Field Museum.)

Kennicott's type of *macrostemma* corresponds in color to that which we have described as phase 1. In 1866 Professor Cope (1866, 306) described a new species which he called *flavilabris*, from two specimens sent to the Smithsonian Institution by Doctor Sartorius, which were labeled "Tableland or Southern Mountains of Mexico." Unfortunately the types are now lost, but according to the description there can be little doubt but that they were identical with color phase 4 as described above. There are at the present time three specimens in the U. S. National Museum (24993–4–5) which are labeled "South Mountains or Micrador Vera Cruz," and were collected by Doctor Sartorius. These are probably the specimens referred to by Cope (1866, 307), which, although he does not mention the resemblance, also seem to be referable to this phase.

In 1885 Cope (1885b, 172) again established a new species (*insigniarum*) on the basis of a specimen taken by himself at Chapultepec, Mexico, giving as its principal characteristics the absence of the dorsal stripe and occipital spots. It is impossible to distinguish the particular form he had in mind from this description, but fortunately both the type and cotype are available and correspond to our color phase No. 3; the cotype especially being a very good example of this style of coloration. In that paper (p. 173), in an attempt to give comparative diagnoses of the forms of this group, he distinguishes *insigniarum* from *flavilabris* by the absence of the dorsal stripe and occipital spots in the former. It will be seen, however, that this can not be done, since there is a dark phase (No. 2) which is similarily characterized

by an obscurity of these markings. In 1892 he apparently recognized this fact and the near relationships of these forms, as he describes them all as forms of *macrostemma*, evidently including *insigniarum* specimens with obscure markings both of the yellow (3) and black (2) phases, since he states that the type of *macrostemma* is intermediate in color between *insigniarum* and *flavilabris*. In 1900 he carried this farther and reduced *flavilabris* and *insigniarum* to the standing of varieties, but defined *macrostemma* (*insigniarum*) as being larger, *darker colored* and having the spots and bands indistinct and the parietal spots generally absent, as distinguished from *flavilabris* with its *brighter colored ground*, yellow labials, stripes, belly, and parietal spots. As we have shown in the description of the color phases, the ground color in the original *insigniarum* form is yellow, so that although Cope was justified in combining *insigniarum* and *macrostemma*, as all intermediate color phases occur, he has limited his description to include only the dark forms, phase 1 and 2, and placed the name *insigniarum* in the synonymy of *macrostemma*, but at the same time excluded the color phase to which it was originally given, putting these specimens with *flavilabris*. That this is actually the case is further shown by the fact that he subsequently labeled several specimens of the yellow phase (3) as *flavilabris*.

As a matter of fact it is absurd to attempt to distinguish subspecies on these color phases, and, indeed, impossible to do so and still observe geographic probability. If we ignore all questions of nomenclature and examine the color phases, it will be found that numbers 1, 2, and 3 may all occur in the same locality and intergrade perfectly, but seem to be quite distinct from phase 4, with its more distinct markings. If we examine the range of the specimens, however, we will find that the color phases 1, 2, and 3 are only represented in the southern part of Mexico, and that they include all of the specimens taken about the lakes in this region (Patzcuaro, Chalco, Xochimilco), while phase 4 is found to the north in Arizona, Chihuahua, Durango, and Guanajuato, and in Veracruz and Puebla. They can therefore hardly be classed as either individual or racial variations, and since they are not sexual, males and females being found of either color, the suggestion arises at once that they may be due more or less to local environmental influences. This explanation is enforced by the fact that the specimens taken about the lakes Chalco and Patzcuaro (the forms with obscure markings) represent the aquatic forms whose habits have been described, while those in the more arid regions are the phase 4. This explanation must be taken with extreme caution, however, for in very few cases is there data with individual specimens. It is advanced principally to call attention to the need of detailed study on this point.

Enough has been said to establish the homogeneity of the form *megalops* throughout its range. This uniformity, which is in har-

mony with the absence of geographic barriers, is expressed in scutellation, tail length, and color. There are, however, variations both in scutellation and color. The color varieties are not individual or sexual, but seem to be partly at least associated with the dampness of the environments. The variations in scutellation and tail length are in the nature of a scarcely perceptible decrease toward the south. This reduction, as shown by our diagrams, is a general one, and involves the number of dorsal scale rows, ventral and subcaudal plates, and supralabials, being best marked in the case of the dorsal scale rows.

Affinities.—If we can base our faith upon the position of the lateral stripe there can be no doubt that *megalops* is a member of the *Radix* group, since there is never any doubt of its position being upon the third and fourth rows, for the greater part of the length. Although posteriorly this stripe seems to descend to the second and third rows, there has not been a single specimen examined or recorded in which it departed from the third and fourth rows anteriorly, even in those specimens with a reduced scutellation. It is in this respect sharply defined from all other forms on the plateau of Mexico, only to the northward (southern Arizona and New Mexico) coming in contact with a similar form.

MARCIANUS.[a]

Description.—We have seen that the arid basins of southern Arizona and New Mexico are inhabited by one species of the *Radix* group, the Mexican *megalops*. It is also the home of another characteristic and well marked form, known as *marcianus*, which is probably entitled to the distinction of being the most pallid form in the genus. This species was described by Baird and Girard in 1853 (1853, 36–37) from a specimen taken near Cache Creek in what is now Oklahoma, and is characterized by the presence of 21–19–17 dorsal rows of scales, 8 supralabials, about 155 ventral plates, about 68 subcaudals, and a tail length of about .23 in the males and .22 in the females. The lateral stripe is very light, on the third row of scales only anteriorly, posteriorly being upon the second and third rows. The general ground color is light brownish yellow, which is in marked contrast to the black markings. In view of the fact that it has for years been considered a subspecies of *elegans*, it may appear strange to some herpetologists that this species should be considered a member of the *Radix* group. We hope, however, to be able to justify our position by showing that there is in reality less difficulty in referring it here than to the other groups in the genus.

[a] *Thamnophis marcianus* (Baird and Girard), Catalogue of North American Reptiles, 1853, pp. 36–37. Includes the *Eutænia elegans marciana* of later writers, and *E. nigrolateris* Brown (1889, pp. 421–422).

Habits and habitat relations.—Rarely is it possible to obtain a sufficient number of records to map in detail the range of any form, but if we know its preferred habitat we can, in doubtful regions, determine more or less accurately the probable extent of its range by the limits of the environmental conditions with which it is usually associated. In the present case such data would be of great value, but unfortunately, as far as we have been able to find, there is practically nothing recorded on the habits of *marcianus,* with the exception of the general conditions of the region it inhabits. I have observed elsewhere (Ruthven, 1907, 589) that it is occasionally at least found in the vicinity of streams, which is in harmony with the known habits of the other arid region forms in the genus (fig. 20).

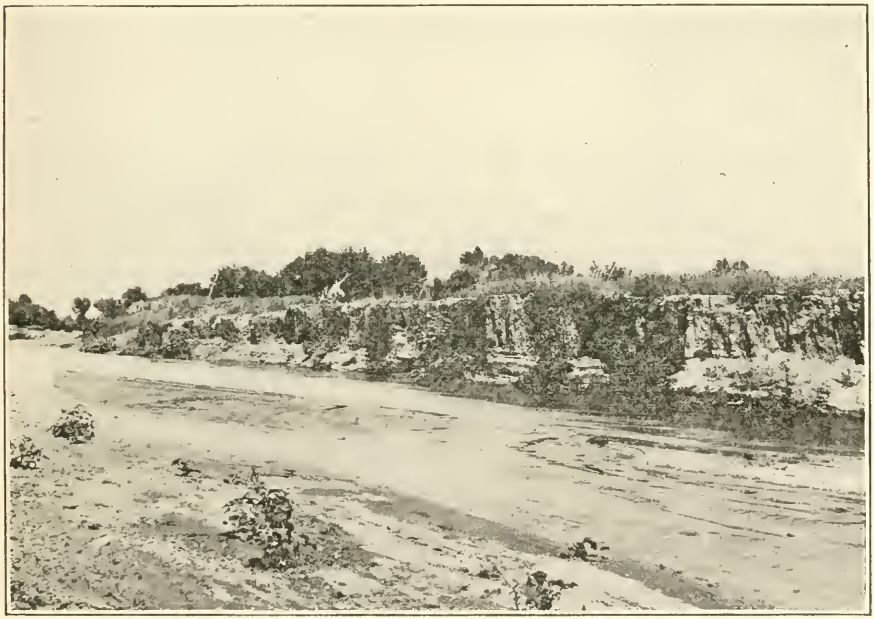

FIG. 20.—SANTA CRUZ RIVER AT TUCSON, ARIZONA. THAMNOPHIS MARCIANUS HAS BEEN FOUND HERE.

Range.—The region inhabited by *marcianus* includes the Proplateau region of southern Arizona, New Mexico, and Texas, the central part of the latter State, and northern Mexico. We have already briefly discussed the geographic and climatic conditions of the Proplateau region, so there remains to be considered only the environmental conditions in the Texas portion of the range of this form. This region may for convenience be divided into two physiographic regions; the prairie-plains region, situated roughly to the east of the Pecos River, north of the thirtieth parallel and west of the ninety-eighth meridian, and the Rio Grande plain, which occupies the triangular area between the prairie-plains, Rio Grande River, and ninety-eighth

meridian. As here defined, the prairie-plains region includes the "Central Province" of Hill and the strip of prairie that extends southward from Austin to the Rio Grande plain. The Rio Grande plain, as we use the term, is synonymous with the "Lower Rio Grande Country" of Hill (see fig. 21).

To the east of the East Front Ranges, the western Texas region descends from the high plateaus bordering the Rocky Mountains in northern New Mexico by a series of broad plains arranged in the form of a great stair (as described by Hill) to the Gulf of Mexico. The higher part of this area constitutes part of the plateau region of western United States and is bounded on the south and east by a

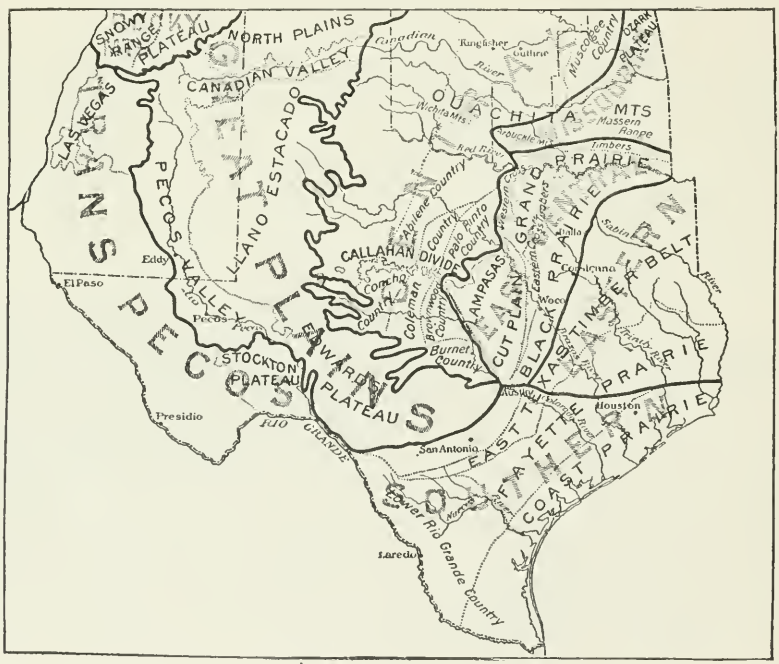

Fig. 21 The natural divisions (environmental complexes) of the Greater Texas Region.

line running from Del Rio to Austin and from here west and north to Oklahoma. To the eastward the plateaus grade down into the prairie region, which forms a broad band across central Texas and extends to the northward beyond the State.

The climatic conditions of these regions are well illustrated by the character of the vegetation. The Trans-Pecos region is a part of the Proplateau region of southern Arizona and New Mexico, and the conditions are very similar to those in the latter States. The rainfall is mostly below 10 inches, and the evaporation is high, which with the scanty rainfall prevents the occurrence of arboreal vegeta-

tion, except on the higher summits. The flora of the plains and the slopes below the timber zones consists of such forms as the sotol, ocotillo, creosote-bush, mesquite, and a host of cactuses.

To the east of the East Front Ranges the climate becomes progressively more moist than that of the Proplateau region, although the rainfall continues below 30 inches to the ninety-eighth meridian. On the sandy plains of the lower Rio Grande, with its dense growths of chaparral and intervening prairies, the conditions are still very arid, owing to the low humidity and small rainfall, but to the eastward the grasses become more mesophytic and grade into the eastern forests near the 98th meridian. To the northward the forest margin is bordered on the west by the mesophytic grass associations of the prairies that rise to the westward to the solid buffalo grass formation of the high plains.

The ninety-eighth meridian, as has been pointed out by Hill (1900) and in more detail by Bray (1901 and 1904), and Bailey (1905), marks in a general way the boundary between the mesophytic forest of southeastern United States and the great grass country of Texas. This doubtless marks equally well the dividing line between the fauna of these two areas. As Bailey has shown, it marks the eastern limit of the mesquite, Texan woodpecker, and Texas rattlesnake.

Owing to the extreme paucity of records, it is impossible to draw the geographic boundaries of *marcianus*, except in a very general way. The range has been defined by Cope (1892, 656) as "restricted to the valley of the Rio Grande from Colorado to its mouth, extending eastward into Texas as far as the Concho and Nueces rivers," but as specimens have been taken in Arizona, the range as given by Brown (1901, 24), "Central Texas to western Arizona" is more nearly correct. But little importance can be placed in locality records for this form until the specimens have been examined. In 1875, Yarrow (1875, 573), in writing of this form, remarked that the last specimens of *vagrans* (*elegans*) seen were at Taos, New Mexico, on the north side of the Picoris Mountains, while on the south side of these mountains *marcianus* was said to occur for the first time, and specimens were listed from "San Ildefonso, New Mexico," "Abiquiu, New Mexico" (3), "Taos, New Mexico," and "Pueblo, Colorado" (2). Unfortunately only field numbers are given for these specimens, so that they cannot be located with certainty, but the only specimens in the U. S. National Museum from these localities bearing the date and collectors recorded by Yarrow are three specimens of *elegans* from Abiquiu (No. 8728), one specimen of *elegans* labeled "New Mexico" (No. 8421), and two specimens of *radix* from Pueblo (No. 8581). The particular specimens from San Ildefonso listed by Yarrow as *marcianus* cannot be determined with certainty, as there are a number of specimens in the U. S. National Museum bearing the same

date and locality. There are, however, two specimens from San Ildefonso (8416–8417) of *eques* that are labeled *marcianus*, while it is to be noted that the only specimens from Taos in the Museum are *elegans*.

With these gross errors confronting us in the literature, it is evident that we can trust neither the general ranges given nor the detailed locality records. I may be excused, therefore, for confining my discussion of the range of this group principally to the specimens that I have examined. Fortunately the doubtful localities are rare, for I have examined the specimens upon which most of the records have been based. I have examined specimens with defi-

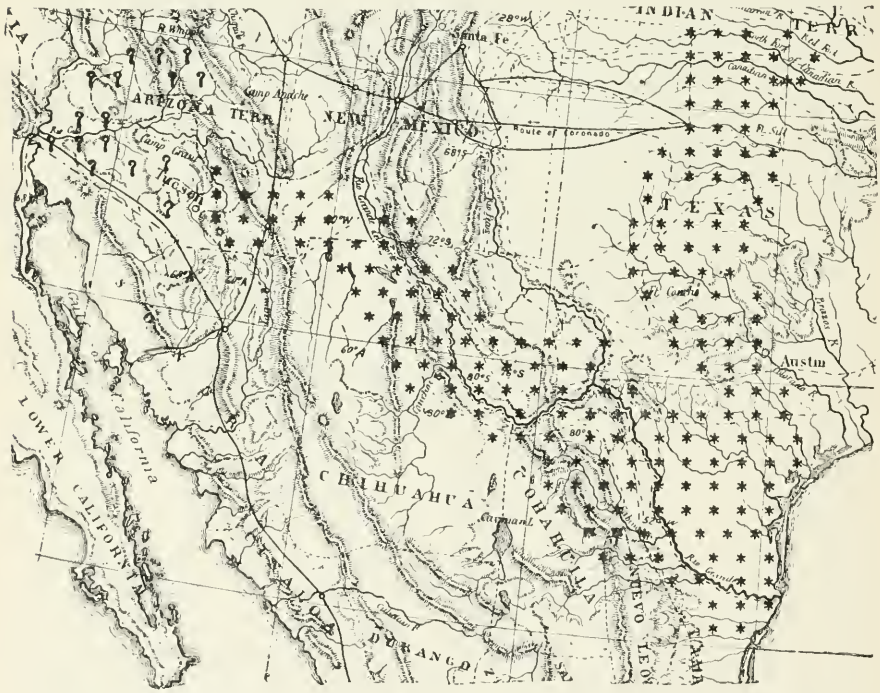

FIG. 22.—DISTRIBUTION OF THAMNOPHIS MARCIANUS, AS INDICATED BY THE LOCALITY RECORDS.

nite locality records as follows: Fort Yuma, California; White Horse Springs, and Fort Supply, Oklahoma; Matamoras and Charco Escondido, Tamaulipas, and Ojo del Diable, Chihuahua, Mexico; Brownsville, San Diego, Point Isabelle, Reutersville, Cameron County, San Antonio, Indianola, Eagle Pass, Pecos, San Angelo, Helotes, Jeff Davis County, "South of Clarendon," Kerrville, Texas; Tucson, Arizona; "Red River, Arkansas."

When these localities are plotted on a map (fig. 22) the distribution of the form is seen to be more extensive than has been generally stated. In the Proplateau region it is known from as far west as Yuma,

Arizona, but, as has been elsewhere stated (Ruthven, 1907, 589), since only three[a] specimens have been recorded from here and this is the only record for the Sonoran desert region in Arizona, they should not be taken as establishing the occurrence of the form so far to the westward, for the locality may not be an exact one. Its northern and southern limits in this State can only be conjectured. The single specimen in the U. S. National Museum labeled "Ojo del Diable, Chihuahua," is the southernmost record for the Proplateau region. Aside from the Yuma records, which consist of one specimen in the Academy of Natural Sciences of Philadelphia and two in the U. S. National Museum, all collected by Major Thomas, no other specimens are known to me from southern Arizona, except three in the Academy of Natural Sciences of Philadelphia, two in the National Museum, and one in the American Museum, all from Tucson. It is probable, however, that it ranges north to the Colorado plateau, although no specimens have been taken at Fort Whipple, where considerable collecting has been done. It is highly probable that it does not range north of this point.

For New Mexico there are no authentic records. As we have seen above, Yarrow's specimens are to be referred to *elegans*, *eques*, and *radix*. Cope (1883, 12) records a specimen taken by Frank Snow at Socorro, but I have been unable to verify this record. Without doubt *marcianus* occurs in the southern part of this State, but its northern limit is a debatable point, for although the high plateau, as in Arizona, may exclude it from all but the extreme southern part, on either side of the Rio Grande, there seems no good reason why it should not occur up the valley of this river at least as far north as Las Cruces.

In the Trans-Pecos region of Texas *marcianus* has been recorded from the Davis Mountains, Jeff Davis County, Paisano, and Boquillas, all localities south of the high plateaus. East of the East Front Ranges the records indicate that it occurs throughout the prairie region of central Texas, and the Rio Grande plain as far south as Charco Escondido, Tamaulipas, north to Fort Supply, Oklahoma, and westward to an undetermined distance on the plains. Clarendon, Pecos, and San Angelo are the most western records for this region, and it will be noticed that these localities mark approximately the eastern margin of the Staked Plains. Whether this indicates the actual western limit of the form in this region, or the lack of specimens from more western localities, can not of course be determined. As in the Proplateau region, however, it is significant that its chief distribution in Texas is confined to the lower altitudes, so that it would not be surprising to find that its western range is limited by the increasing altitude of the high plateau, the Pecos records possibly indicating that it pushes to some extent up

[a] Erroneously given as two in the paper mentioned.

the river valleys. The eastern limit of its known range is represented by the Victoria, San Antonio, and Austin records, and is approximately the 98th meridian, which, as we have seen, marks the boundary between the prairie type of biota of central Texas and the forests of southeastern United States. The most northern record is Fort Supply, Oklahoma (see p. 69). The range of this form then may be defined as the arid deserts of northern Mexico, southeastern Arizona, southern New Mexico, and southwestern Texas, the arid plains about the lower part of the Rio Grande, and the prairie region of central Texas.

Variation.—The individuality of *marcianus* is so pronounced that it stands out in strong relief from the other forms in the region which it occupies, and makes the question of its affinities a very puzzling one. At the same time it is a very homogenous form and apparently varies but little either geographically or individually, as shown by the fact that but one other variety (*nigrolateris*, Brown, 1889), based on an anomalous specimen, has been made from it, a form since dropped.

Any discussion of the variations of *marcianus* must be made with great caution in consequence of the inadequate number of specimens available. Although the material in the American, Field, and U. S. National Museums, and the Philadelphia Academy of Natural Sciences have been examined, besides a number of specimens from private collectors, it has been impossible to obtain more than 60 individuals of this form. Fortunately these appear to be scattered over most of the range of the species, and this with the apparent lack of marked individual variation makes it possible, even with but a few specimens from the different localities, to examine the geographic variation. In every specimen examined from Tucson, Arizona, to Oklahoma, the scale rows are 21–19–17.

The supralabials are more variable; at Tucson they are constantly 8 in 5 specimens; at San Antonio, 8 and 9; in Cameron County they are 8 in the great majority of cases, occasionally 7, and in one case 9 on one side, with an average of 7.9; in Oklahoma 8. Evidently from the material at hand it is impossible to say that there is any geographic variation in this character. As regards the ventral plates, the females have 151 to 156, in the specimens labeled "Yuma, Arizona," and the males 157 to 162, with an average (all specimens) of 155.6; at Tucson two males have 160 and three females 156–159, average 158.4. At San Antonio a female has 149 and a male 157; while in Cameron County the range in variations of both males and females are lowered, in only two cases reaching 160 and falling as low as 144, the average being 151. At White Horse Springs, Oklahoma, a male has 157 and a female 155. These figures seem to indicate a slightly larger number of gastrosteges in

Arizona and a decrease in the Rio Grande Plain, but, while the average for Cameron County probably approximately indicates the actual conditions, the other averages are based on far too small a number of specimens to be reliable. The most striking fact shown by these figures is the uniformity in the number of ventral plates throughout the range of the group, for although enough records are not at hand to reveal any slight trends of variation if they are present, enough have been secured to indicate beyond question that such variations, if they actually exist, must be small, as the averages from the different localities differ less than the amount of individual variation in any set of records. The evidence of the subcaudal plates is especially unsatisfactory, for it is evident that not nearly enough records have been obtained to determine even approximately the range of sexual variation. The specimens labeled "Yuma" vary from 62 to 71, average 66.6. At Tucson the average is 68.6; in Cameron County the average is 68.6, while at White Horse Springs a male has 71. Here again we find that the averages when males and females are combined falls between 66 and 69, a difference of but 4 scutes and one that could easily be due to the predominance of either sex in the averages.

As in the case of the subcaudals, it is impossible from the material to determine the limits of sexual variation in the tail length, yet an examination of the measurements indicates that the males, as a rule, vary from .22 to .26, the general length being between .23 and .24. The females seldom vary more than two points about .21, the range being from .19 to .22.

It is not to be inferred from the above discussion that there is no geographic variation in the form, for it is possible that when a large enough number of specimens have been examined to establish the limits of sexual variation it will be found that there is some variation in different parts of the range. But nevertheless the evidence now available indicates that if such a variation is present it is small, for even this small amount of material, subject as it is to irregularities caused by individual and sexual variation, demonstrates unquestionably a close uniformity in scutellation and tail length throughout the entire range.

In color this uniformity is even more strongly enforced, and can be no more plainly expressed than by the statement that, owing to the constancy of coloration throughout the extent of its range, no variations have been considered of specific or subspecific value. The ground color is usually light brownish yellow above, with three rows of alternating black spots; the first row on the first, second, and occasionally part of the third rows of scales, the other two rows alternating between the lateral and dorsal stripe, on the skin and all but the keels

of the involved scales. The stripes are very light yellow; the lateral stripe on the third row only anteriorly, and posteriorly on the second and third; the dorsal on the median and about one-half of the adjacent rows encroached on to the median row by the upper row of spots. Large nuchal blotches and a distinct postoral crescent. Head dark olive; first, second, third, seventh, and eighth supralabials olivaceous, the fourth, fifth, and sixth, with the preoculars and second and third postoculars, being light yellow. The third, fourth, fifth, and sixth supralabials margined with black. Belly light yellowish ash. In older specimens the ground color becomes darker, and the spots seem to retreat from the scales, although still distinct on the skin. The spots below the lateral stripe also become indefinite, but the stripes themselves retain their position. This variation, however, is apparently due to age, as we have said, and as far as we have been able to see there is no marked geographic differences in color.

Affinities.—Considered in the totality of its characters, *marcianus* stands out in decided contrast to the other forms in this region, and, as we have stated before, this individuality has in great part delivered it from the confusion that has resulted in the efforts to classify many of the other forms. The attempts that have been made to determine the relationships of *marcianus* have, however, led to several extraordinary results. It was described in 1853 by Baird and Girard (1853, 36–37) as a distinct species and no attempt was made to establish its affinities for thirty years. In 1883 Garman (1883, 25 and 138) included it as a subspecies of *sirtalis*, which, however, means little as regards genetic relationships, for we find this writer including as varieties under this species such divergent forms as *radix*, *elegans*, and *sirtalis*. Cope in 1892 (1892, 656) reduced it to the rank of a variety in the *Elegans* group, on the basis of the position of the lateral stripe on the second and third rows, and the possession of 21 scale rows and 8 upper labials, thus allying it to *elegans* and *hammondi*. This arrangement was followed by Brown in 1901 in his review of the genus (1901), but in 1904 (1904, 470) he changed his mind and derived it directly from *parietalis*, with no explanation as to his reasons for so doing. These dispositions of the form are unsatisfactory, to say the least.

It will be observed that the placing of *marcianus* in the *Elegans* group rested upon the assumptions that the lateral stripe is to be considered on the second and third rows of scales, which is far from established, and that racial affinities are indicated by similarity in the number of scale rows. The latter, as we have seen, is also far from being the case, and we are thus freed from the necessity of accepting any of the solutions of the problem that have been based on these grounds. We must search for similarities with other forms

in the light of our knowledge of the method of variation and of geographic probability.

The only character, so far as I can see, that would justify an attempt to derive this form from *parietalis* and relate it to *eques* is the pallid color. In general the ground color is nearly the same as in *eques*, while the paleness of the labials and stripes, and the similarity in the arrangement of black markings, is so close as to result in frequent confusion. Color, as we have seen, is the least important of our criteria, but it is worthy of note that in spite of the pallidness in *eques* the lateral stripe is always distinctly on the second and third rows throughout the entire length (instead of on the third row only), even in the region in which it occurs with *marcianus*. In scutellation there is very little resemblance between *marcianus* and *parietalis* or *eques*. The latter in Texas has mostly 8 supralabials and always 19–17 scale rows, and *parietalis* has usually 7 supralabials and always 19–17 scale rows. According to our observations on the variation in the number of scale rows, *marcianus* could have been derived from either *parietalis* or *eques* by an increase in the number of scales, but the further difficulty presents itself that both of the latter species (especially *eques*) overlap the range of *marcianus* considerably without effecting the purity of the types, and the only way by which they can be considered akin is to invoke the aid of some form of isolation (ecological or physiological), which the evidence of similarity does not call for. The difficulty of adopting such an explanation would be less if there were any signs of intergradations in these forms; but, as it is, *marcianus* has constantly 21–19–17 rows and *eques* and *parietalis* 19–17. Its relation to the *Elegans* group is not, however, so easily disposed of.

In the possession of 21–19–17 scale rows and 8 labials *marcianus* agrees closely with *hammondi* and *elegans*, and while the number of ventral and subcaudal plates is normally less and the tail shorter, the inference might well be drawn that the similarity is an expression of relationship. Nor does the lateral stripe confute this, for it is the general pallidness of the ground color that apparently makes the stripe indistinct except upon the third row. Geographically also it seems, at the first glance, as if this relationship was confirmed, for the range of *hammondi*, *elegans*, and *marcianus* seem to be exactly contiguous, and do not overlap. There are certain facts, however, that confute the evidence furnished by the similarity in scutellation. First and foremost, is the lateral stripe to be considered as being upon the second and third rows? Secondly, *hammondi* is markedly distinct in color from *marcianus* even in the regions where they approach each other, and this distinctness is supported by the general topography of the body, as expressed in a longer, narrower head, increased number of urosteges, etc., and the presence of two

preoculars. Very evidently it seems to us that if we grant a relationship between these forms it must be a distant one, for there can be no question as to their distinctness at present.

As regards *elegans*, the geographic probabilities may also be conceived as favoring a close relationship, for it seems very evident that in Arizona, New Mexico, and Texas, where the range of the two forms come together, *elegans* is restricted to the plateaus and *marcianus* from them, and the differences between the two forms may be explained by this separation of their respective ranges and as the result of the different conditions to which they are exposed. Thus *elegans*, even in the most southern localities from which it is known, San Ildefonso, New Mexico, presents so often a scale formula of 19–21–19–17 as to indicate plainly a tendency toward a reduction in scutellation, which may possibly be correlated with the higher altitude of its habitat, while in coloration it resembles so closely dark specimens of *marcianus* as to make it difficult at times to refer specimens to the proper form. Furthermore, the generally light color of *marcianus*, as I have shown, may be correlated with the aridity of its habitat. What, then, is the objection to this attractive view? If we take for granted that *elegans* is a dwarfed form of a stock that possessed a larger number of scale rows, it seems to us that we have reason to expect that correlated with the decrease in the number of scale rows there at least will not be an increase in the number of ventral plates, although the tail length and urosteges may vary independently, as we have seen. If the reduction in the different series of scales on the body is correlated, as seems to be the case, then *elegans* has apparently been derived from some stock with a larger scutellation than *marcianus*, since it has a decidedly larger number of ventral plates. This problem will be taken up again when the *Elegans* group is considered, but it seems to me, although the material is as yet much too meager to warrant any decided opinion, that the neighboring species of the *Elegans* group all give evidence of being derived from a different source than *marcianus*, and the opposite.

If this point be granted, I have now excluded *marcianus* from all except the *Radix* group, and it remains for me to examine its relations to the other forms of this group. The fact that the first row of spots covers the first and second rows anteriorly seems to furnish some evidence that the stripe is to be considered on the third and fourth rows. Still, this is, of course, not conclusive, and the lateral stripe must still be considered noncommital, although the fact that it occurs on the second and third rows posteriorly is not an insurmountable objection, as it also has this position in *megalops*, in which it is anteriorly upon the third and fourth rows. The number of labials is much the same in both *marcianus* and *megalops*, as is also the tail length. On the

other hand, the number of dorsal scale rows, subcaudals, and ventrals are apparently less. Thus there are no serious objections to deriving *marcianus* from *megalops* on structural grounds (the geographic probilities will be considered later), but still there is no satisfactory proof that such a relationship actually exists, and we must look elsewhere for evidence of its relation to the *Radix* group.

On the north *marcianus* meets *radix*, and when the scutellation of these forms is examined it is seen that there is no great break between the forms in this regard. The number of scale rows and labials are the same near the common boundary, and, notwithstanding the fact that *marcianus* has a smaller range of variation in the number of ventrals (157–163) as compared to *radix*, 159–172, in the same general region, the averages are very close, while the tail length and number of subcaudals are approximately the same. In spite of the fact that the color of *radix* is usually darker, the general pattern is very similar to that of *marcianus*. Indeed, in western specimens of *radix* the ground color becomes quite light, so that in the case of two specimens from Oklahoma, in the possession of the Field Museum (Nos. 630, 631), it is impossible to tell whether they are to be referred to *radix* or *marcianus*. In these specimens the color is dark brownish yellow, the first and second rows light ash. The spots are in three very distinct, alternating rows on the skin and all of the involved scales; the first row being on the first and second rows, the other two between the stripes. The lateral stripe is distinct, narrow, and anteriorly on the third and part of the fourth rows, posteriorly on the second and third. Anteriorly the spots tend to fuse into large blotches. Eye rather small. Head dark olive. The first, second, seventh, and eighth supralabials are more olive, the third to sixth, inclusive, being light yellow; all are margined with black, the fourth, fifth, and sixth the heaviest. This coloration is so like that which exists generally in *marcianus* as to make it evident that these specimens are closer to this form than any other. The points that indicate an affinity with *radix* are the fact that the first and second rows of scales differ in color from the lateral stripe and are covered by the first row of spots, and that the lateral stripe seems to be partly on the fourth row. If I am right in considering that these specimens from Oklahoma indicate that *marcianus* and *radix* are directly related, the lateral stripe in the former must be considered as belonging on the third and fourth rows of scales, which throws the form with the *Radix* group.

Whether *marcianus* and *radix* intergrade at the present time along their common boundary, or not, is not a question to be decided on the basis of two specimens, but, be this as it may, it must, we think, be conceded that there is such a very close similarity in scutellation and color between the two forms as to warrant the conclusion that they are directly related, while if we consider the lateral stripe in the former

as a modification of the third and fourth row position, there is little difficulty in placing *marcianus* in this group. A prime difficulty which presents itself is the necessity of accounting for the fact that it overlaps in part the range of *megalops*, with which, if we can trust the evidence of the lateral stripe, it must be closely related. Before this objection can be considered, it will be necessary to obtain much more information on the distribution of both *marcianus* and *megalops* in southern Arizona, for, as has been shown, but very few records of either form are at hand from this region, while some of those that are available are, to say the least, open to question. However, it must be admitted that *marcianus* undoubtedly occurs at Tucson, while *megalops* exists in southern New Mexico (Duck Creek), so that the forms unquestionably overlap. Still, it seems to us that the similarities are close enough to warrant the working hypothesis that *marcianus* is an offshoot of *megalops* that pushed across the deserts of northeastern Mexico and into the Trans-Pecos and western Texas region, and here obtained its individuality, so that as it moved eastward it found its range limited by the transition line between the prairies and the forest, while in its subsequent westward movement into the range of the parent stock (*megalops*) its differentiation in structure or habits was sufficient to keep the two from interbreeding. To the northward, in Arizona and New Mexico, its range was limited (except in the valleys) by the high plateaus, but in Texas the extension of the semiarid prairie-plains furnished a highway to the northward, along which it spread, becoming (in Oklahoma and southern Kansas) reduced in the number of scale rows and darker in color to constitute the form now known as *radix*.

This is a bold hypothesis to be made on the basis of such a small number of specimens, but, granting the fact that more observations may overthrow it entirely, it seems to me, in the light of our present knowledge, to be the most satisfactory explanation for the origin of the form. At all events, if it arouses discussion and stimulates further investigation, it will have served its purpose.

RADIX.[a]

Description.—I have already noted that along its northern boundary, in Oklahoma, *marcianus* approaches another form, *radix*, with which it is apparently closely related. However this may be, the specimens now at hand indicate that throughout most of its range *radix* is a distinct and well-defined form, which it is comparatively easy to distinguish.

[a] *Thamnophis radix* (Baird and Girard), Catalogue of North American Reptiles, 1853, p. 34. Includes *Eutaenia haydeni* Kennicott, *E. radix twiningi* Coues and Yarrow, and *E. radix melanotaenia* Cope.

Fortunately in this form no doubt attaches to the position of the lateral stripe, as it is always distinctly present on the third and fourth rows anteriorly, and generally on the third only posteriorly after the fourth is dropped. The scutellation may be generally described as follows: 21–19–17, 19–21–19–17, or 19–17 dorsal scale rows; 7 (8) supralabials; 142 to 176 ventral plates, and 57 to 87 subcaudals. There is so much variation, however, as we shall see later, that this general statement has but little value. The tail length is quite constantly about .23 to .26 in the males and .20 to .23 in the females. The ground color is some shade of brown, with the usual three stripes, the laterals greenish or bluish, and the dorsal yellow, frequently inclining to orange. The lateral spots, as in *megalops* and *marcianus*, are in three distinct rows, except when the ground color is so dark as to obscure them.

Habits and habitat relations.—Radix probably enjoys the distinction of having furnished us with as much or more information concerning its habits than any other form in the genus, and yet it will be very apparent from the following summary that our knowledge is still very incomplete. Taylor (1892, 324), in writing of its habits in Nebraska, says that *radix* "in food habits agrees with specimens of *E. sirtalis* var. *parietalis* of the same size. Earthworms and insect larvæ seem to constitute the bulk of their food." Elsewhere the food of large individuals of *parietalis* is said to be the leopard frog, while specimens "not exceeding two and one-half feet in length almost always contain within their stomachs specimens of the common earthworm."

In 1882 Dr. Henry Brous, in the American Naturalist (1882, 564), recorded the following notes on the habits of this snake:

> Several of the summers I passed upon the plains were preceded by rainy springs, swelling to unusual height the small streams which become inhabited by small fishes. During the drought of hot summers the receding waters left the fishes in shallow pools within creek beds, an easy prey to their numerous enemies.
>
> The midday heat caused numbers of snakes to seek shelter from the sun, and the garter-snake (*Eutaenia radix*) in particular chose water at this time. Here the fishes, unable to escape or find deep cool water, were unwilling cotenants with the snakes. The latter are fond of fish, and would devour great numbers of the smaller ones, chasing them from one part of the shallow pool to the other. When the fishes were in water too shallow to swim in, or were struggling upon the sand, they would be seized by the snakes, who would feed upon them until unable to contain more. The snakes would follow the fish through the water, diving and remaining submerged some time. I did not observe them swallow air. (See Am. Nat., Jan., 1880.) Snakes evince more than ordinary energy and sagacity in capturing fish; half a dozen will congregate within a small pool, all acting in concert.
>
> Mr. J. L. Wortman, who had charge of a scientific party last year, informs me that while fishing one day he caught numbers of chub (*Cyprinidæ*) and, throwing them on the mud, was surprised to see but few remained. While quietly continuing to replace those so singularly missing, he observed a garter-snake seize and swallow one of the fish 6 inches in length. There were two of these snakes reaping the benefit of Mr.

Wortman's skill. Upon opening the snakes one was found to contain six fishes. The headwaters of the Smoky Hill and Big Horn rivers abound in this aquatic *Eutaenia radix*.

Doctor Coues (1878, 278) has also observed the habits of *radix* in North Dakota and Montana:

> In the more fertile portions of the Red River Valley itself, throughout the Red River region, from Pembina to where the Coteau de Missouri crosses the line, it is the characteristic Ophidian, the principal and almost only representative of its order, outnumbering all the others put together. * * *
>
> In the more fertile portions of the Red River Valley itself this snake may be found almost anywhere in the brush and herbage. Out on the drier prairie beyond it is chiefly confined to the pools and streams, or their immediate vicinity. Numbers are found basking together on the muddy borders of the sloughs or among the masses of aquatic vegetation where they find ample subsistence during the summer months in

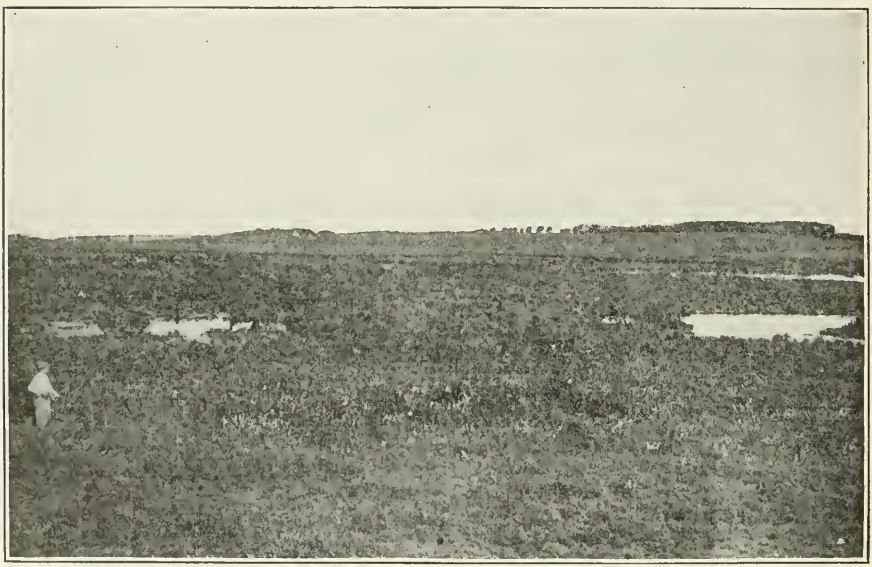

FIG. 23.—HABITAT OF THAMNOPHIS RADIX AND T. SIRTALIS PARIETALIS. SLOUGH (OUTLET TO ELBOW LAKE), CLAY COUNTY, IOWA. THE MARGIN OF THESE GRASSY SWAMPS IS APPARENTLY THE MOST FAVORABLE HABITAT FOR T. RADIX IN THE PRAIRIE-PLAINS REGION, AND WITH IT IS FOUND ASSOCIATED T. SIRTALIS PARIETALIS.

tadpoles, young frogs, and various water insects. They are themselves preyed upon by hawks, especially the Marsh Harrier (*Circus cyaneris hudsonius*) and Swainson's Buzzard (*Buteo swainsoni*). They are less active than some of the slender species, are readily caught, and when captured make little or no resistance. Only the largest individuals assume for the moment a defensive attitude and attempt to bite; most may be at once handled with impunity.

My own observations on the habits of *radix* in northwestern Iowa agree in the main with those of Doctor Coues. The topography of this region is characteristically glacial, and consists principally of moraines with intervening lakes, ponds, or swamps, according to the depth of the depressions. The swamps, locally known as "sloughs" (fig. 23), are characteristic of the prairie region. The

water is not deep enough, except in occasional pools, to prohibit a rank growth of grasses and sedges, which grow for the most part in clumps on compact elevations formed of decaying roots and rhizomes. Between these hummocks the substratum is soft, plastic mud, with usually a varying amount of water over the surface. This habitat is a very favorable one for frogs, and all stages of the leopard frog are abundant, from the tadpoles in the pools to the large adults hopping about in the grass. The margin of these swamps is also preeminently the preferred habitat of *radix*, and the collector can at any time during the summer months pick up several dozen specimens of various sizes in a short time at almost any of these places. There can be no question as to at least one feature of their food in this habitat, for it is a common experience while walking about the margins of a slough to hear the hoarse "quark" of a frog in distress, and a brief search will almost invariably reveal a leopard frog in the jaws of one of these snakes. The size of the frog which they can eat with comparative ease is scarcely creditable. Tadpoles are also eaten voraciously, and I have opened the stomachs of snakes which were fairly gorged with them. The snakes swim freely about in the pools and probably capture small fish as well as tadpoles.

About the margins of the lakes it is also abundant, although generally it does not appear to be as numerous in this habitat as about the sloughs. Abundant as it is in swampy habitats, however, *radix* is far from being confined to these conditions, and we have often taken individuals on the hills (fig. 24) half or three quarters of a mile from water during dry hot days in July and August. In such places, however, they are found commonly only in the morning or evening or on wet and cloudy days, seeking the protection of holes during the heat of the day. Their food habits on these ridges are necessarily somewhat different than in the sloughs. I have observed specimens in August in the stubble, and in and about the shocks of grain, capturing the small tree frog (*Chorophilus nigritus*). These tree frogs are, however, of rather rare occurrence in this region, and for its food *radix* must depend upon other forms. One of these is that staple article of diet for so many of the plains forms in the fall—the grasshopper. This insect occurs in great abundance in late summer and furnishes food for such a variety of animals as wolves, foxes, badgers, gophers, cranes, grouse, and hawks. I have often seen these snakes coiled up on a shock of wheat with a grasshopper's legs protruding from the corners of its mouth, and there can be little doubt that it forms an important part of the food in the upland habitats. It is very possible that they also rob the nests of the field mice which are often made in the shocks of grain, for young mice are often found in the nests at this time which have not as yet gotten their eyes open, and would thus fall an easy prey. During September they have also been seen in newly

opened furrows in the plowed fields seizing the earthworms that are turned out by the plows. In the stomachs of specimens from a patch of upland prairie in Clay County, Iowa, I found two small mammals and a bird. All of these had undoubtedly been found dead, as they were all badly flyblown. This indicates that *radix*, like other members of the genus (see notes on *sirtalis* and *elegans*), will occasionally eat dead animals. However, even in the upland habitats, the principal food of *radix* in the prairie region is the leopard frog. Where there is long grass this frog may, in western Iowa, be found quite commonly a mile or more from water. In view of the intense heat and drouth of the hot summer days it seems rather

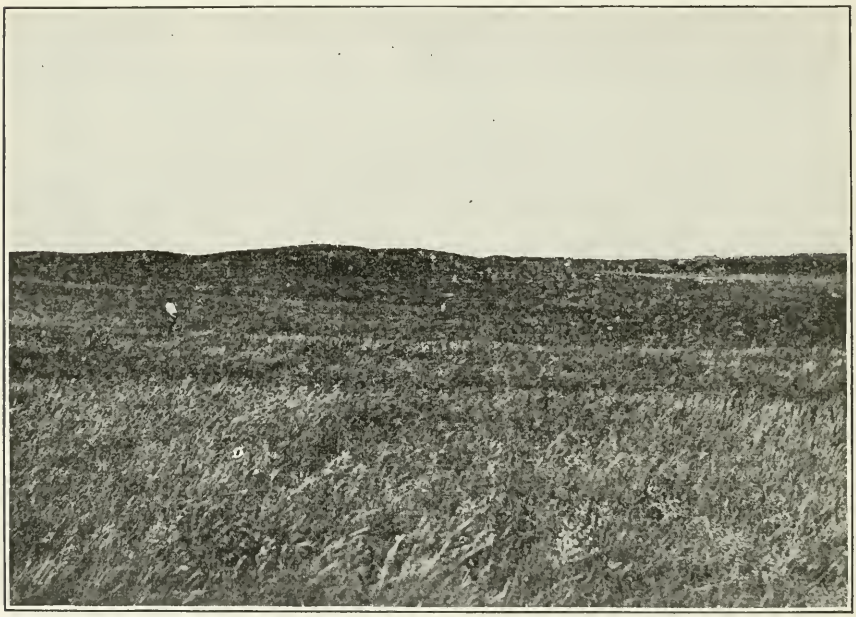

FIG. 24.—HABITAT OF THAMNOPHIS RADIX AND T. SIRTALIS PARIETALIS. MORAINIC HILLS IN CLAY COUNTY, IOWA. T. RADIX IS FREQUENTLY FOUND ON THESE GRASSY RIDGES, A MILE OR MORE FROM WATER. T. SIRTALIS PARIETALIS IS ALSO FOUND IN THIS HABITAT, BUT ONLY RARELY.

remarkable that the frog can live in these habitats. Its ability to do so is apparently due to the fact that the dense growth of grass is wet with dew for the greater part of each day, for where it is grazed closely frogs are very scarce.

Coues states that they are preyed upon by hawks. I have seen this several times, but an even greater enemy is the American bittern, which nests in great abundance about the margins of the sloughs. These birds feed voraciously on both frogs and snakes.

Very little is known of the breeding habits of *radix*. Coues and Yarrow (1878, 278) state that "the greater part of the females observed in July and August will be found pregnant, the young number-

ing sometimes as many as 30 or 40." I have examined pregnant females in July, August, and September in western Iowa that contained from 17 to 25 young, and have kept females in captivity that gave birth to young on August 31 and September 7, 8, 29, and 30 (1907). By the size of some of the embryos examined I believe that broods may appear as early as the latter part of July.

The period of gestation is uncertain. Coues states that "individuals were taken in coitu in September and part of October. So as it is unlikely that young are born after this date, this observation might be taken to indicate a period of gestation protracted for the greater part of the year." This observation is difficult to explain. It is hardly possible that more than one brood is raised each year, and those that appear in October are probably belated first broods. Likewise it is highly improbable that the period of gestation is protracted over the winter, since such is not the case in the other species of the genus in which coition has been observed. The probabilities are that coition takes place in the spring, and that Coues was mistaken in his observation or was viewing abnormal cases.

Coues (1878, 278–279) writes that *radix* is abundant along the northern boundary of the United States, and Branson (1904, 364) adds that "It has a wider distribution and occurs in greater numbers than any other Kansas garter-snake." I have already observed that it is very common in northwestern Iowa. At times it occurs here in such numbers as to become a veritable nuisance. Particularly was this true in the summer of 1892, when it became extraordinarily abundant. But, while it occurred in numbers about the barns and outbuildings on higher ground, it was most noticeably abundant in the sloughs and about the lake shores, which fairly teemed with them. Hundreds of individuals could be observed lying on the rocks along the shores of these lakes or swimming freely in the water. This remarkable development was doubtless due to the advent of unusually favorable conditions, and it may be significant that this was an exceptionally wet year. After 1892 the number apparently fell off rather suddenly, for they were not observed to be noticeably abundant until 1896, when, according to a number of residents, they again became very numerous, although not as much so as in 1892.

The abundance of *radix* over most of the prairie region and the fact that it is here of general distribution and not confined to a particular habitat, indicates, it seems to me, that, unless it changes its habits, we may expect that toward the limits of the prairie it will become more closely confined to the conditions to which it has become adjusted in the heart of its range, and will finally be limited in a general way by the boundary of the prairie-plains conditions.

Range.—The geographic location of *radix* is the prairies and plains of central North America north of the 37th parallel. This region is a continuation of the prairie and plateau regions of Texas, and like these regions is bounded on the west by the Rocky Mountains and on the east by the forests of eastern North America. The prairie-plains region lies against the foot of the Rockies, at an elevation of about 5,000 feet, and from here eastward descends gradually in broad flat surfaces to eastern Nebraska and Kansas. From here eastward it extends as a slightly descending peninsular extension of the treeless conditions of the great plains, through Minnesota, Iowa, Missouri, and Illinois into the western part of Indiana, everywhere abutting against the forests of eastern United States. The topography of the greater part of the prairie peninsula is glacial, and is characterized by a thick mantle of waste evenly spread, or heaped into rolling moraines or loess bluffs, with intervening depressions containing lakes, ponds, or swamps, according to their depth. The characteristic vegetation consists of grass formations that not only occupy the uplands, but also the sloughs. The river valleys and lake shores alone support arborescent associations.

The western part of this prairie region (approximately between the eastern boundary of Kansas and Nebraska and the 98th meridian) is a continuation of the prairie region of central Texas, with which it connects in a narrow belt just west of the Ozark Highlands, and it extends to the northward in eastern Kansas, Nebraska, and Dakota far to the north of the Canadian boundary. The plains region which lies between the prairie and plateau regions includes the Staked Plains of Texas and extends to the northward beyond the Canadian boundary. The topography is without striking relief and the valleys of the rivers are broad and shallow. The vegetation is characterized by the peculiar bunch-grass formation, although the valleys carry the prairie formations far beyond the prairie region proper.

The drainage of the entire treeless area of central North America north of the 37th parallel is tributary to the Mississippi, with the exception of the areas that lie within the hydrographic basins of the Great Lakes and the rivers draining into Hudson Bay and the Arctic Ocean. In the United States the streams flow eastward across the plains, the larger ones (the Arkansas, Platte, and the Missouri) having their origin far up in the Cordilleras. Across the great plains they flow in broad shallow valleys, but as the altitude increases toward their source the main waterways sink their channels into the level surface of the plateaus, dividing this major physiographic feature into a number of table-lands whose margins are deeply dissected into bad lands by the secondary tributaries. Topographically, therefore, the aspect of the prairie-plains region is essentially that of a level plain; there are no distinct physiographic barriers, and

the whole area is united into a uniform feature by its treeless condition. It is the grass-land area of North America. In spite of this uniformity, however, the division of the area into the plains and prairie regions is a real if not a well-marked one, and seems to be due to differences in the climatic conditions.

Extending as it does from Texas nearly to the Arctic Circle, and having an extreme width of about 18 degrees of longitude, the prairie-plains region presents a considerable variety of climatic conditions. In general it is characterized by hot summers and mild winters, but extremes of temperature are not rare. The western part of the region is quite arid, for much of the moisture carried by the prevailing westerly winds that is not precipitated on the western slopes of the Pacific Mountains is condensed and precipitated as the air is again compelled to rise on the western slopes of the Cordilleras, so that in their subsequent course east of the Rockies these winds are desiccating agents. The plains are thus characterized by small rainfall (less than 30 inches) and a large proportionate evaporation. Transeau (1905, 884) has shown that when the ratios between the rainfall and evaporation are mapped for different localities, the plains are marked by a rainfall equal to 20 to 60 per cent of the evaporation called for. This in part accounts for the more xerophytic nature of its flora. Approximately between the 97th and 98th meridian the rainfall increases to the eastward above 30 inches, and the rainfall-evaporation ratios rise to between 60 and 80 per cent, and the more favorable conditions are marked by the presence of the more mesophytic grass formations of the prairie region. Where the evaporation ratios rise above 80 per cent the prairie region gives way to the dense forested area of eastern North America.

Specimens of *radix* with definite locality labels have been examined as follows: Lake Winnepeg, Rush Lake, Regina, Canada; Pueblo, Greeley, Fort Collins, Colorado; Du Page County, Sycamore, Chicago, Berwyn, Lake County, Palos Park, Mount Carmel, Illinois; Clay County, Palo Alto County, Ames, Iowa; Peabody, Fort Riley, Kansas, Fort Snelling, Mankato, Minnesota; St. Charles County, St. Louis, Madison County, Missouri; Threeforks, Miles City, Fort Benton, Montana; Loup Fork, Fort Pierre, Nebraska; Pembina, Turtle Mountains, Mouse River, North Dakota; Hermosa, South Dakota; Dallas, Texas; Racine, Madison, Kenosha, Wisconsin; "Bridgers Pass," Fort Laramie, Wyoming.

As we have previously said in the discussion of the geographic conditions, the prairie-plains region is not to be distinguished from the plains and prairies of central and western Texas. At the present time, however, we have no evidence that the form enters the latter except possibly in the extreme northern part, in Oklahoma and Indian Territory, although the southern margin of the range of *radix*, like the

northern boundary of *marcianus*, is very imperfectly known. The southernmost localities in the plains from which *radix* specimens are definitely known are Scott and Marion counties, Kansas, so that the ranges of *radix* and *marcianus* are at least adjacent if not adjoining or even overlapping. There is no evidence at present to indicate an overlapping, except the single specimen recorded by Cope from Dallas, Texas. This is without question a typical specimen of *radix*, but the record should be held in reserve until it has been substantiated by further collecting; it suggests, however, that the range of *radix* may be found to extend farther south in the prairie region of central Texas than on the more arid plains to the west, which would be in accordance with our knowledge of the habitat relations of the form. If the respective ranges of *marcianus* and *radix* overlap in the debatable territory in Oklahoma and southern Kansas it can not be to any great extent, and we believe that we are safe in considering that the southern boundary of *radix* on the plains approximately conforms to the northern boundary of *marcianus*.

The northern termination of the domain of *radix* is even more imperfectly known than the southern, and it is difficult to even approximate it, for here, as to the south, the plains conditions are evidently continued far beyond the range of the form. The notes and specimens of Coues (1878, 278) indicate that it is abundant on the northern boundary of the United States from the valley of the Red River to the foothills of the Rocky Mountains, but that it also occurs farther north is indicated by the specimens in the U. S. National Museum from Regina and Rush Lake, Assiniboia, British Columbia, which at present seem to be the most northern localities in which it has ever been taken.[a] The extent of its northern occurrence is probably dependent upon its ability to endure the lower temperatures that characterize this region, and since snakes are as a rule a warm climate group, and apparently can not stand extremely cold conditions, we may expect to find the northern limits of the area occupied by *radix* not far north of Regina.

As was noted in discussing the habits of *radix*, even in the more moist parts of its domain, it apparently prefers the wet swamps to the dryer uplands. From this it may be expected that the western boundary of its range is not determined by the Rockies themselves, but by the high arid table-lands that border them on the east. It is easily conceived how a form of more or less general distribution on the prairies but having a preference for moist habitats might, on the more arid plains to the west, become more closely confined to these conditions, to its exclusion from the plains, and be carried far west-

[a] There is a single specimen (No. 9251) in the U. S. National Museum labeled "Lake Winnepeg" collected by Doctor Gunn, which, although a typical specimen of *radix*, can not be considered here, for the locality is evidently a general one.

ward in the valleys of the streams, as they are sunk into the plains by the increase in elevation, in a manner somewhat analogous to the extension of the range of the prairie types into the plains region (Pound and Clements, 1900, 74–78). Of course, the records available are too meager to ascertain the actual state of affairs, but it may be significant that within the region where the plains reach a height of 5,000 feet the Colorado and Montana localities at which *radix* has been taken (Pueblo, Fort Collins, and Greeley, Colorado, and Threeforks, Montana) are all in the valleys of the Arkansas, Platte, and Missouri rivers, which have cut their channels well below the higher levels of the plateaus.

It is unfortunate that reliance can not be placed on the locality given for three specimens of *radix* in the U. S. National Museum (Bridgers Pass), but the locality given is probably but a general one, so that we have no evidence at present as to what extent, if any, this form has pushed westward through this gap in the Rockies. The record suggests, however, that *radix* may follow the tributaries of the North Platte well across the Laramie plains, that form a break in the continental divide at this point.

To the eastward of the plains region the records indicate that *radix* occurs throughout the prairie region. The northern limit to which it is actually known to occur may be represented by a line drawn from Pembina, North Dakota, southward through Fort Snelling, Minnesota, and Madison, Wisconsin, to Racine, on Lake Michigan. This line corresponds quite closely to that of the common boundary between the northern coniferous forest and the prairie in these States, and it might be concluded, since *radix* is a prairie form, that this approximately represents the actual northern limit in this region. There can be little doubt, I think, that the margin of the prairie in Minnesota and Wisconsin does determine the northern limit of the principal distribution of *radix* in this region, but as the tension line between the forest and prairie is not a sharp one, but marked by a transition zone of brush prairie and open woods, while for a considerable distance within the forest area proper there are tongues and patches of prairie conditions, it is very probable that *radix* will be found in these habitats somewhat within the forest area. If a line be drawn from Lake in the Woods to Mille Lac, Minnesota, and from this point through Dunn, Eau Claire, and Jackson counties, Wisconsin, to Racine, it will roughly indicate the northern limit of the outlying habitats related to the prairie, and I believe that *radix* will not be found to occur much beyond this line.

On the south and east the prairie peninsula is also limited by the forest, and its border is the tension line between the prairie and the deciduous forest of southeastern United States. As mapped by Pound and Clements (1900), this boundary lies mostly to the north of Mis-

souri, bending southward in Illinois to include most of that State above the latitude of St. Louis. Above this latitude in Missouri and southern Iowa, however, the extensive meadows and open character of the woods relate this region to the prairie proper, and it is doubtless for this reason that we find *radix* extending southward to St. Louis, Missouri, and, although its southern boundary is not definitely known, it probably approximately coincides with the border of the southeastern deciduous forest that lies a little to the south of these localities, curving around the northern boundary of the Ozarks to the 98th meridian.

Illinois north of the 39th parallel is true prairie, and *radix* is known to occur throughout the State above St. Clair and Wabash counties, but in western Indiana, which is not a prairie State, the prairie comes in contact with the forest and breaks up into grassy peninsulas and islands that might be expected to introduce *radix* well beyond the prairie proper. Nevertheless, the most eastern localities for which we have authentic records are Chicago and Mount Carmel, Illinois. In 1881 Hay (1881, 738) recorded a specimen of *radix* in Butler University. He says of this specimen that "it is a good and well-characterized specimen of *Eutænia radix*, that I have every reason to believe was found at Irvington, near Indianapolis. The species is found at Bloomfield, Illinois, and is included by Dr. W. H. Smith, in his Catalogue of the Reptiles and Amphibians of Michigan, as occurring in that State." In 1887 (1887, 65) he includes it in his list of Indiana Reptiles and Amphibians. Doctor Cope (1888, 400–401) described as a new variety (*melanotænia*) two specimens of *radix* presumably from Brookville, Indiana, and we have examined two specimens from Purdue University, belonging to the Butler collection, and presumably also from Brookville. Unfortunately, however, doubt attaches to the locality of all of these specimens. Hay did not seem absolutely sure that the Butler University specimen came from Irvington, and in the case of the Purdue specimens no locality is given, while a third is labeled "Illinois; collector, A. W. Butler." I believe, therefore, that while it is very probable that *radix* will be found in western Indiana, particularly in meadows and clearings, the present records can not be accepted as evidence of its occurrence in the State.

In general, then, the range of *radix* may be defined as the plains and prairie regions of central North America. Owing to its preference for wet, marshy habitats it is more generally distributed in the prairie region and pushes slightly to the eastward beyond this feature in the encircling brush prairie zone, but is limited by the margin of the forest of eastern North America, while to the westward it enters and extends entirely across the plains region, possibly by adhering, in a general way at least, to the valleys of the large streams, which also support a well-defined flora of the prairie type (fig. 25).

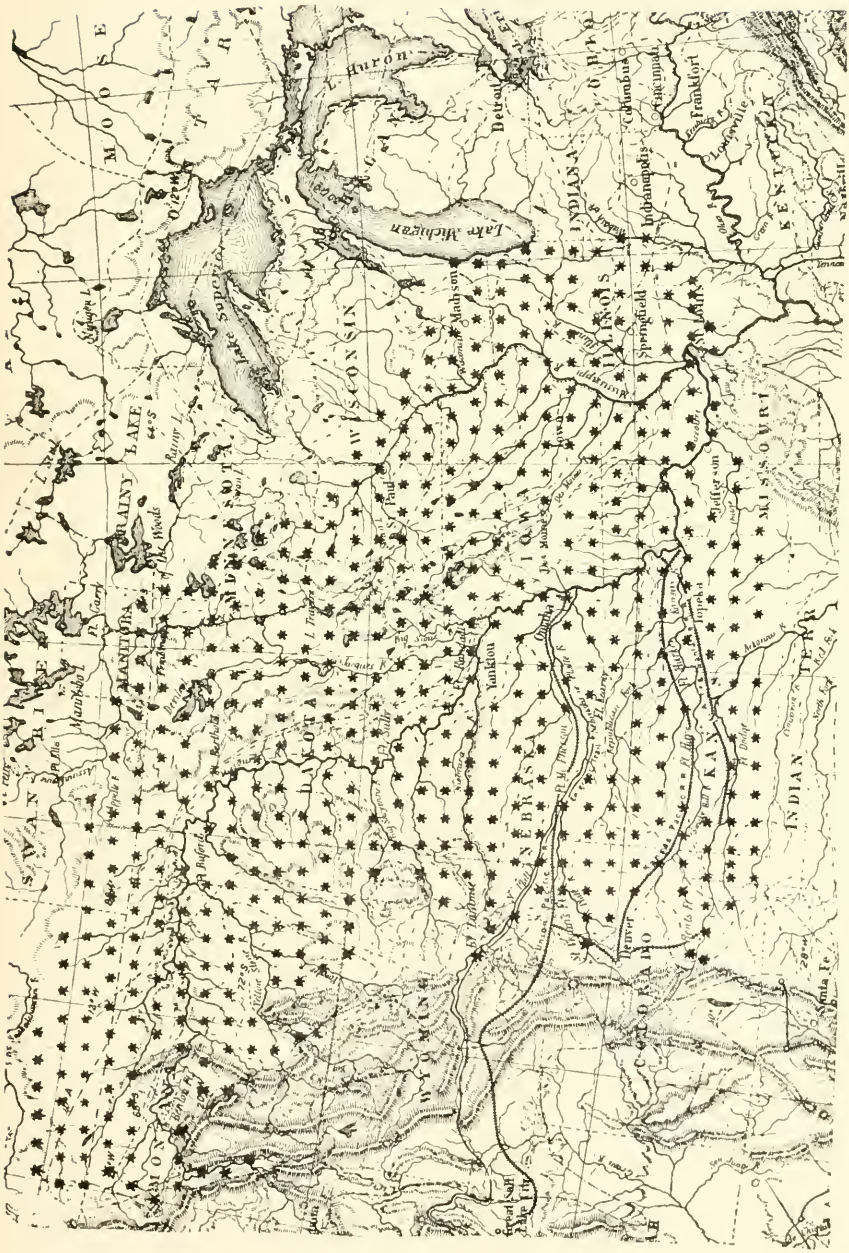

FIG. 25.—DISTRIBUTION OF THAMNOPHIS RADIX, AS INDICATED BY THE LOCALITY RECORDS.

Variation.—After examining hundreds of specimens I believe it to be unquestionable that we have to deal here with a single form which is sharply defined from the other garter-snakes of the prairie-plains region. Generally speaking, it may be defined as having 21–19–17, 19–21–19–17, or even 19–17 scale rows, 7 (8) supralabials, 142 to 176 ventrals, 57 to 87 subcaudals, and the lateral stripe on the third and fourth rows of dorsal scales, but while this description will serve very well for analytical purposes, it gives no clue to the relationships, and we have to examine the variations in detail. For the sake of unity of treatment, as well as for the fact that this character is less variable than the others, the number of dorsal scale rows will first be examined. The number (maximum) for *radix* has generally been given as 21, although the type had 19. Brown (1901) gives the number as usually 21, but occasionally 19, and Cope (1892, 651) states that the only specimen which he had examined with 19 rows

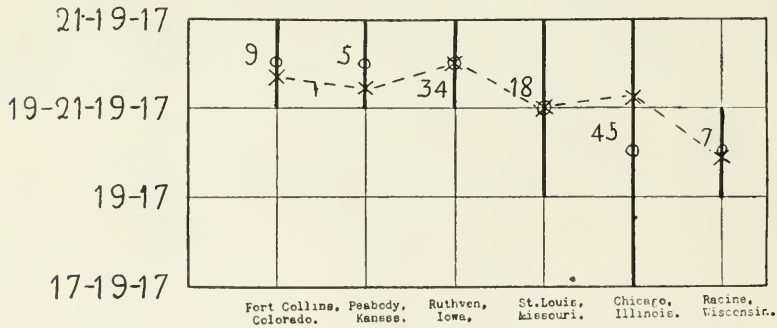

FIG. 26.—DIAGRAM SHOWING THE VARIATION IN THE DORSAL SCALE FORMULA IN THAMNOPHIS RADIX.

was the type An examination of the following diagram (fig. 26) will show the actual state of affairs.

This table shows clearly that *radix* is not characterized by a single dorsal scale formula in any part of its range, but the formula 19–21–19–17 occurs the most frequently in all localities. While, however, the range of variation is extensive, and the arithmetical mean remains nearest to the formula 19–21–19–17, we believe that the diagram is correct in indicating as it does that there is a tendency toward a larger number of rows in the more western localities. This is apparently shown both by the displacement of the mean from the formula 21–19–17 toward or below the formula 19–21–19–17, in the eastern localities, as well as by the lowering of the minimum number toward the formula 19–17 or below, in the same direction.[a]

In plotting this diagram we have only used the localities from which we have the largest number of specimens, and still the series from the

[a] This decrease in the number of rows in eastern localities explains how the type of the species (which came from Racine, Wisconsin) came to have 19 scale rows.

plains region are so small that our conclusions might with justice be objected to on this ground. If we examine all of the specimens from the region west of the 97th meridian, however, regardless of locality, we find that there is not a single specimen in the lot that has less than 19–21–19–17 scale rows in the dorsal series, although about half have the formula 21–19–17, while in but a small series from Racine 19–17 is

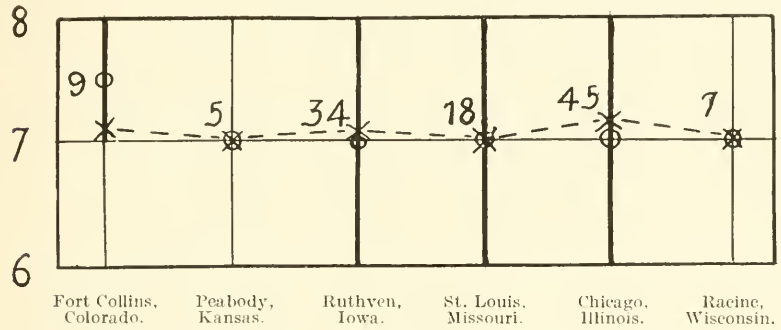

FIG. 27.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS RADIX.

the common formula. I believe, therefore, that it is indisputable that a decrease in the mean number of rows toward 19–21–19–17 rows or less takes place in the western part of the prairie region.

The number of superior labials have been variously given as 7, 8, and 7, occasionally 8. I have plotted the number for various localities in the diagram, fig. 27, and an examination of this table shows that the average number is very close to 7 throughout the

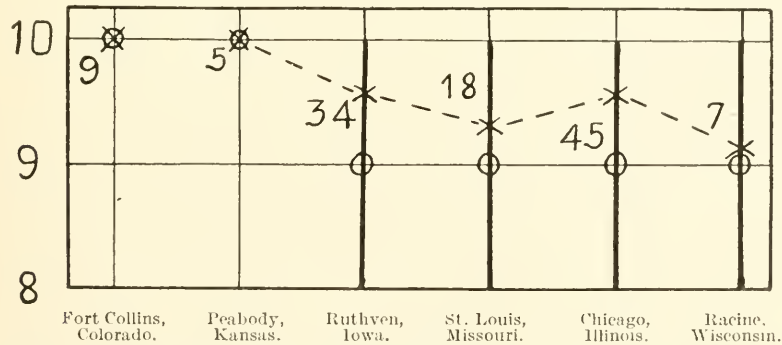

FIG. 28.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF INFRALABIALS IN THAMNOPHIS RADIX.

range. Indeed, so close does the mean approximate 7 that no geographical variation in the average number can be detected with the series at present available. On the other hand, it should be pointed out that it is only in the specimens from the prairie region that less than 7 superior labials are found. Very similar conditions exist in the case of the inferior labials. Thus, in the diagram, fig. 28, it will

be seen that there may be 8, 9, or 10 in this series, but that 8 infralabials have only been found in the prairie region. In the case of both the superior and inferior labials we readily admit the possibility that larger series of plains specimens may destroy this apparent tendency toward a decrease in the number of plates to the eastward, but we do not think that it is probable, for, as in the number of dorsal scale rows, an examination of all of the plains specimens has failed to turn up a single specimen with 6 superior or 8 inferior labials, so that if these numbers exist in this region it must be in small proportion.

If the tables represent the true state of affairs, then *radix* evidently tends to become slightly reduced in the number of dorsal scale rows and inferior and superior labial plates in the prairie region. (The mean number of subcaudals and ventrals, subject, as they are, to a considerable range of sexual and individual variation, can not be determined in the small series at hand.) However this may be, one thing at least is certain, and that is that *radix*, as a form, does not have a constant number of scale rows and labial scutes. This is shown not only by the frequency of the variations that occur, but also by the fact that the dorsal scale formula is so frequently 19–21–19–17 (which is a transition stage between the formula 21–19–17 and 19–17) and the fact that generally when the labial formula is 8/10 the third superior and the corresponding inferior labials are noticeably reduced. This is significant, as it indicates, we believe, that the form is a dwarfed offshoot of a stock with a larger scutellation.

The variations in color have but thrice been thought of subspecific value. In general, as previously described, the ground color is brown, with three stripes (the lateral being on the third and fourth rows and the dorsal on the median and halves of adjacent rows), and three rows of black spots on the skin and involved scales. In western specimens, from Kansas and Nebraska, the ground color is light brownish olive, and the black spots are consequently very distinct. The dorsal stripe is very conspicuous, being usually bright orange yellow, and often covering more than the median and halves of the adjoining rows, the lateral stripe being usually pale yellow and less conspicuous. The interspaces on the skin between the spots are usually whitish. This coloration was described as a species (*haydeni*) by Kennicott in 1860 on the basis of a specimen from Fort Pierre, Nebraska, that was further characterized by having the interspaces on the skin between the lateral spots red instead of the usual whitish. This color in the type specimen has now faded, but a specimen in the possession of the Academy of Natural Sciences of Philadelphia (No. 16619) from Peabody, Kansas, shows the same coloration. In this individual the interspaces on the skin and the edges of the involved

scales are a dull brick red, giving rise to a pattern that resembles very much some specimens of *parietalis* from the same region. This specimen is, however, the only one which we have observed with this development of red pigment, and the trait must be considered as of rather uncommon occurrence and not as typical of specimens from this region.

The "*haydeni*" type of color, as above described, may be considered in general as typical of specimens from South Dakota, Wyoming, Nebraska, Colorado, and Kansas, but to the east and north of these points the ground color becomes darker brown, and even black, somewhat or entirely obscuring the spots. The stripes in prairie specimens remain much the same as in western ones, but the dorsal tends to lose its golden tinge. Doctor Coues (1878, 277–278) states that Pembina specimens are "olivaceous-blackish or obscure brownish black," and that this color occurs as far westward as the Coteau de Missouri on the northern boundary, but that in the arid region of the upper Missouri and Milk rivers it is replaced by a form whose principal character is seen in the increased breadth and intensity of coloration of the dorsal band, especially on the anterior portion. To this western form Coues and Yarrow (1878, 279–280) gave the name of *radix twiningii*. Western Iowa specimens are as a rule darker than those from Kansas and Nebraska, and show their close color affinity mostly in the golden yellow dorsal stripe, and it is evident that these specimens are to be considered as intermediate between the more pallid western pattern and its darker eastern representative. That the color tends to become darker to the northward as well as to the eastward is shown by the fusing of the spots on the skin in specimens from Turtle Mountain and Regina.

The third color variety has been described by Cope (1888, 400–401) on the basis of two specimens reported to have been taken at Brookville, Indiana (see p. 80). The principal characteristic of these specimens was the elongation and fusion of the gastrostegeal spots to form a broken band along each side of the abdomen; not an uncommon occurrence in the darker eastern representatives of this form.

None of these phases differ sufficiently to indicate well-marked forms or to be given subspecific rank, and they have been dropped by later writers.

In the above discussion of the variations of *radix* I have purposely excluded from consideration three specimens (Nos. 30872, 30873, 30874) in the U. S. National Museum from Milwaukee County, Wisconsin. These specimens are typical *butleri* in coloration, and the lateral stripe is upon the third and adjacent halves of the second and fourth rows. In scutellation they agree both with *butleri* and with reduced specimens of *radix*. The scutellation is as follows:

Table of scutellation.

U. S. Nat. Mus. No.	Supra-labials.	Infra-labials.	Oculars.	Temporals.	Sub-caudals.	Ventrals.	Total length.	Tail length.	Dorsal scale rows.
							mm	*mm*	
30872	7	8–9	1–3	1–1 1–2	66	146	462	123	19–17
30873	7–8	10	1–3	1–2 1–1	64	145	397	97	19–17
30874	6–7	8–9	1–3	1–2 1–1	66	142	450	120	19–17

Definite conclusions can not be based upon such a small number of specimens, but, granting the accuracy of the locality, it should, I believe, be concluded that these specimens are more than usually dwarfed specimens of *radix*, and that the lateral stripe has become slightly displaced in the reduction in the number of scale rows below 21. It is true that the writer has seen little evidence that the lateral stripe tends to be disturbed in position when the fourth row is lost (see also pp. 36–37), but in at least one specimen (Cat. No. 525, U. S. N. M., from Racine, Wisconsin), which has 19–21–19–17 rows, the lateral stripe apparently tends to descend upon the second row, where the fourth row is dropped to leave less than 21. This point should be carefully tested by the examination of a large series of specimens from eastern Wisconsin.

Affinities.—If the lateral stripe is a safe index there can be no uncertainty as to the inclusion of *radix* in the group to which we have given its name, as there is no doubt as to the position of the lateral stripe on the third and fourth scale rows. Just what its relation is to *marcianus* is undetermined at present, but that it is not distantly related to *megalops* is quite evident both from the position of the lateral stripe and general coloration. Cope, in his assertion that *megalops* is the representative of *radix* in Mexico, apparently recognized the similarity of the forms, as did also Brown in 1904 (1904, 471), when he stated that "*E. radix* is a connecting link on the one hand with *E. proxima*, * * * and on the other in the southwest with *E. megalops*."

If, as I believe, *marcianus* is a member of the *Radix* group, it is not likely that *radix* and *megalops* are directly related, and this improbability is enforced by the gap between their respective ranges. It seems more probable that *marcianus* constitutes a link between *radix* and *megalops*, and the closeness with which its range coincides with the region between these two forms lends support to this view. At any rate, *radix* can not at the present time be connected with any other form in the same or adjacent regions, with the exception of *butleri*, which will be discussed later. It differs constantly from *sirtalis*, *eques*, and *elegans* in the position of the lateral stripe, and from *proximus* and *sauritus* in the same region by the increased number of scale rows and the persistently shorter

tail. It is difficult to determine what basis Brown had for the statement that it is a connecting link between *proximus* and *megalops*, other than the general relationship expressed by the position of the lateral stripe, for the range of *radix* and *proximus* overlap to a considerable extent without affecting the purity of either type. Rather it seems, as I shall try to show later, that *radix* and *proximus*, although both members of the same division (see table, p. 40), have had an independent origin from a common stock.

It has already been noted that to the eastward on the prairie peninsula *radix* exhibits a tendency toward a reduced scutellation, and that in this reduction the scale formula 19–17 is approached. This brings *radix* very close to another form (*butleri*), whose western limit, as far as we know at the present time, is close to the eastern limit of *radix*, and makes it necessary to examine this form before the affinities of *radix* in this direction can be discussed.

BUTLERI.[a]

Description.—East of the prairie peninsula, in Indiana, Ohio, southern Michigan, and western Pennsylvania, *radix* is replaced by a form which, like it, is a very distinct and well-marked one. In this form, which has received the name of *butleri*, the ground color is dark olive brown, the lateral spots when visible on the scales being small and restricted to the scale rows adjacent to the stripes, along which they tend to form narrow broken black borders. On the skin these spots are very seldom to be distinguished in definite rows, being more often partially fused, leaving the interspaces irregularly arranged. The dorsal stripe is usually on the median and adjacent rows, and is bright yellow anteriorly but quickly fades out to a dull yellow posteriorly. The lateral stripe is broad and conspicuous, occupying all of the third and most of the second and fourth rows anteriorly, but posteriorly, where the fourth row is dropped, it falls on the second and third rows only, and retains this position to the vent. Anteriorly the color of the lateral stripes is bright yellow; posteriorly they are generally somewhat duller, still retaining, however, their yellow tint. The first row of scales is but little, if any, lighter than above, which serves to accentuate the conspicuousness of the lateral stripes.

The scutellation may be summarized as follows: Dorsal scale rows 19–17, occasionally 17–19–17–15, superior labials 7 or 6, ventrals 132 to 154, subcaudals 49 to 68.

Butler's garter-snake has had a rather peculiar history. Described in 1888 by Cope, on the basis of a single specimen said to have been

[a] *Thamnophis butleri* (Cope), Proc. U. S. Nat. Mus., XI, p. 399. Includes *E. brachystoma* Cope, in part *E. sirtelis* Brown, in part *E. sirtalis obscura* Cope, and in part *E. sirtalis obscura* Morse.

taken at Richmond, Wayne County, Indiana, the type remained for many years the only specimen known. In 1901 Mr. Brown (1901, 27) noted that there were two specimens in the Academy of Natural Sciences of Philadelphia labeled "Miami River" which had been identified as this form by Cope, but as these with the type were the only specimens known at the time he considered them rather anomalous specimens of *sirtalis*, on the basis of the similarity of scutellation. In 1894 Doctor Stejneger (1894, 593–594) recorded a specimen collected in Waterloo County, Indiana, that corresponded closely to Cope's description of *butleri*, and contended for the distinctness of the species. Later the writer (1904, 289–299) found it to be common in southern Michigan, and has subsequently examined material from various parts of Indiana, Ohio, and western Pennsylvania, which indicates that it is a common form in these States, as well as a distinct species.

At first sight it seems rather surprising that a form as common as this one has proven to be should have remained so long unobserved in an area that has been so well worked. The explanation that at once suggests itself is the one put forward by Stejenger—that it has been confused with other forms that resemble it. This has proven to be the case, for we have found specimens from southern Michigan in the Cope collection in the Academy of Natural Sciences of Philadelphia, labeled both "*sauritus*" and "*sirtalis*," but perhaps the most striking instance is that it has frequently been confused with the questionable form *obscura*. It has always been a doubtful question to those who have considered the matter as to just what form or combination of characters the name *obscura* has been considered to apply by those who have used it. Cope distinguished it from *sirtalis* by the fusion of the lateral spots on the skin, a rather dubious character. A possibility of error immediately arose in that *butleri* is characterized by an obscurity of these spots, and, although the type specimen of *obscura* was clearly *sirtalis*, as will be shown later, subsequently to its description Cope labeled two specimens from Michigan in the Philadelphia Academy collection as "*obscura*" which are clearly *butleri*. *Butleri* in coloration somewhat resembles *sauritus*, and Cope (1888, 399) stated that *obscura* "resembles at first sight the *E. sauritus*," thus shifting the name *obscura* to include *butleri* specimens. The basis for this statement were the two specimens from Indiana, which he referred to *obscura* and which were probably *butleri*, although the original description of *butleri* immediately follows. It is also very likely that the specimen recorded by Hay (1892b, 526) as possibly belonging here was also a *butleri*, as he quotes Cope's statement that *obscura* resembles *sauritus*. One of the specimens listed as *obscura* by Morse (1904, 134) also proves upon examination to be *butleri*.

The only other form which has been confused with *butleri* is the *Eutaenia brachystoma* of Cope. *Brachystoma* was described as distinct on the basis of the small number of ventrals and superior and inferior labial plates in the type, and although the reduction in specimens from Pennsylvania is considerable, I have already given my opinion (Stone, 1906, 165) that they represent dwarfed specimens of *butleri*. I have also shown (1904) that the specimens referred to *brachystoma* by Clark (1903, 83–87) are typical *butleri*.

Habits and habitat relations.—It is not to be expected from the history of this form that much would have been recorded on its habits,

FIG. 29.—HABITAT OF THAMNOPHIS BUTLERI. CREEK AT LIMA CENTER, WASHTENAW COUNTY, MICHIGAN. T. BUTLERI IS FOUND COMMONLY ON THE BANKS OF SUCH STREAMS IN SOUTHERN MICHIGAN.

when so little has been ascertained of the habitat relations of forms which have been well known for fifty years or more. In southern Michigan I have only taken it in the immediate vicinity of water, either about the margin of swampy places or on the banks of streams (fig. 29). This may be a coincidence, but it is in accord with all of the specimens collected throughout the range which have habitat data. I have found them most frequently by overturning boards, etc., in such places, although they are also found crawling about in the long grass and herbage.

It is in disposition a rather sluggish snake, seldom attempts to defend itself, and when surprised is usually easily captured. The ease with which they are captured is in part due to their inability to escape, owing to the extreme awkwardness of their movements on land. When moving slowly this is scarcely noticeable, but when they attempt to move rapidly to escape capture their efforts are peculiarly odd and ineffective. The movements consist in throwing the body in long curves in a manner closely analogous to the wiggling motion by which garter-snakes swim in deep water, and which results in much movement and muscular effort, but very little progress. This movement may be greatly augmented by putting the snake on a smooth surface, but it is not entirely due to the nature of the surface, as it can scarcely make any headway on a surface where *sirtalis* will glide away with comparative ease. This is one of the most striking characteristics of *butleri* and was first noticed by Reddick (1895, 261), who comments upon it in the following words: "It is short and chubby, and its movement is very characteristic of it. It does not have the gliding movement of *E. saurita* nor the swift and active movement of the *Natrix sipedon*, but seems rather to exert a large amount of force to do little crawling. The movement is so characteristic that I believe anyone having once seen the peculiar way in which it tries to hurry itself away would ever after be able to recognize it at a distance."

Fortunately no doubt attaches to the species which Mr. Reddick had, for the specimen upon which this observation was based has been examined, and it is unquestionably a *butleri*. The movement seems to be very similar to the method of locomotion described for the so-called *atrata* specimens of *ordinoides* by Ditmars (1907, 227).

Observations upon the food habits of *butleri* are but fragmentary. As announced in 1904, it is fond of earthworms and small frogs, but I have since found that in captivity it apparently prefers small fish. As a rule it is impossible to get them to take either worms or frogs if dead, but it is apparently a matter of unconcern to them whether the fish be alive or dead, as they will greedily eat specimens of the latter which have begun to decompose. Young individuals four or five days old will eat as many as three or four small minnows successively.

Females taken in July are usually pregnant, and the number of young is apparently small. In the specimens examined the number of embryos is about twelve to fifteen. One specimen which was taken in late July, 1905, and kept in captivity gave birth during the first part of August to ten young. The members of this brood were not all born on the same date, but appeared at different times

between August 7 and 20, a difference of thirteen days. This is an unusual occurrence among the garter-snakes, and is undoubtedly abnormal, for, as far as we have observed, it has been invariably the rule that the entire brood appeared within a few hours at most. We have seen but one other specimen give birth to young, and there were four in this brood. The young when but a few days old will struggle eagerly with earthworms or minnows, capturing the latter in a small dish of water or taking them from the fingers. For the first three or four days they are very secretive and can be seen only by overturning the moss and stones in the cage, except when they come out to feed. They have not been observed to feed during the first three days, but after this they will come out freely to gorge themselves on fish, returning again beneath the stones when satisfied. One of these young snakes was kept for three months, in which time it attained to the respectable length of 150 mm.

Range.—The area occupied by *butleri* may be considered geographically as an extension of the prairie-plains region, which gradually rises to the eastward and merges with the Allegheny plateau. The entire region was overridden by the ice sheets of the Glacial epoch, and the topography is determined by the thick mantle of glacial waste which has been spread over the underlying rock surface, as till sheets, moraines, outwash aprons, etc. The drainage is entirely to the Mississippi by way of the Ohio and its tributaries, with the exception of the small area in southern Michigan, northern Ohio, and northwestern Pennsylvania, which lies within the drainage basin of the Great Lakes.

The climate of the region is for the most part mild and rather humid, as is evinced by the character of the vegetation. The whole region is forested, with the exception of small scattered patches of prairie and a small area in western Indiana and southwestern Michigan, which is encroached upon by the extreme eastern end of the prairie peninsula. The rainfall of 30–35 inches that characterizes the prairie increases in this region to about 40 inches, and with this increase, as Transeau (1905) has shown, there is also a rise in the rainfall-evaporation ratios to 80–100 per cent. The forest is of the broad-leafed deciduous type of southeastern North America, but as over the greater part of the region under consideration (Ohio, Indiana, southern Michigan) the rainfall is less and the evaporation greater than in the southern Appalachians, where this forest has its principal development, the condition may be considered intermediate between those that accompany the development of the forest in the southeastern United States and those which obtain on the prairie, and the effect of the difference of conditions upon the vegetation is shown by the more open character of the woods on the uplands. It is generally

within this area of oak openings and open groves on the higher ground, which Transeau has shown to be associated with a rainfall-evaporation ratio of 80–100 per cent, that Butler's garter-snake is found (see Transeau's map, 1905, 885).

Specimens of *butleri* have been examined from the following localities: Ann Arbor, Chelsea, Ypsilanti, Washtenaw County, Brighton, Livingston County, Olivet, Eaton County, Pontiac, Oakland County, Michigan; Turkey Lake, Kosciusko County, Lake Maxinkuckee, Marshall County, Waterloo, De Kalb County, Indiana; Sandusky, Erie County, Columbus, Franklin County, "Miami River," Ohio; Franklin, Venango County, Port Allegheny, McKean County, Pennsylvania.

From these records it will be seen that Butler's garter-snake ranges over most of Indiana, Ohio, southern Michigan, and western Pennsylvania, but its exact limits can nowhere be more than approximately fixed, for the locality records are extremely few. In Michigan it has not been taken north of Pontiac, Oakland County, nor west of Olivet, Eaton County, but it is a very common form in both of these localities and doubtless extends farther north. South of this latitude it is a common snake in eastern Michigan, while the various localities in Indiana represent nearly the entire length of the State (Waterloo, De Kalb County; Turkey Lake, Kosciusko County; Lake Maxinchukee, Marshall County; and Richmond, Wayne County). Although the specimens in the Academy of Natural Sciences of Philadelphia labeled "Miami River" are also marked "Indiana," which would indicate that they are from the extreme southeastern corner of the State, the accuracy of the record can hardly be relied upon, and, as Mr. Brown has remarked (Ruthven, 1904, 289), they are probably from Ohio.

At the present time we know of but two authentic locality records for Ohio. We have already noted that one of the specimens which Morse (1904, 134) records as *sirtalis obscura* is a *butleri*. An examination of his material shows that his specimens of *obscura* comprise four garter-snakes from Columbus, Ohio, collected by Kellicot (not as Morse gives it, Sandusky and Columbus, collected by himself). Two speciments are *sirtalis*, but one an undoubted *butleri*. Although Morse apparently did not find this snake at Sandusky, it is a very common form there, and the Museum of the University of Michigan has received a number of specimens from Mr. E. L. Mosely, which were collected in that locality. Columbus is the southernmost definite locality from which *butleri* is known in Ohio, which is in nearly the same latitude as the most southern Indiana record, that of the type (Richmond, Wayne County). How much farther southward it occurs can only be conjectured, but as it is apparently less common

in these localities than to the northward the southern margin may be placed tentatively at the Ohio River.[a]

If we admit for the time being that *butleri* and *brachystoma* are identical, we find that for twelve years after its description the type of the latter (which was taken in Franklin, Venango County) represented the only Pennsylvania locality from which the form was known to occur. In 1905, however, Mr. H. F. Fowler, of the Academy of Natural Sciences of Philadelphia, secured a second specimen (Stone, 1906, 165) near Port Allegheny, McKean County. This specimen is of interest, as not only extending the range considerably to the eastward, but as also probably representing approximately the eastern

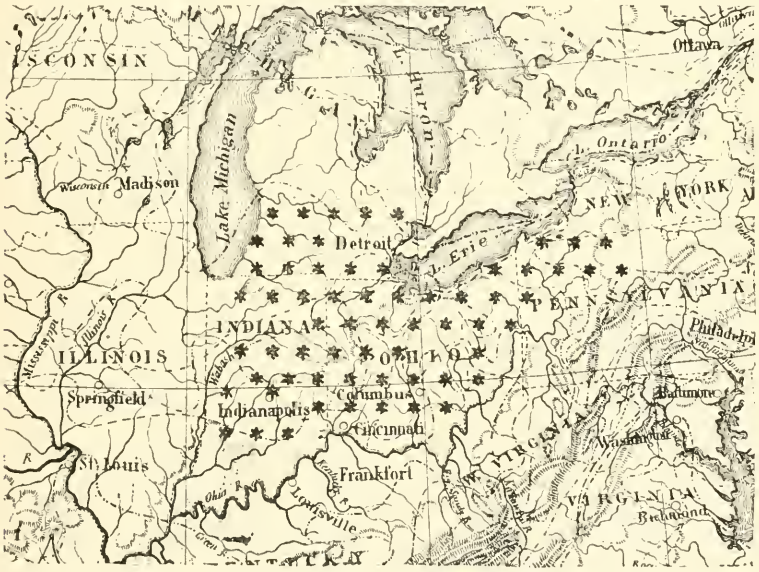

FIG. 30. DISTRIBUTION OF THAMNOPHIS BUTLERI, AS INDICATED BY THE LOCALITY RECORDS.

limit of its occurrence. These specimens will be further discussed in the consideration of the variation of the group.

At this point mention should again be made of the three specimens in the U. S. National Museum from Milwaukee, Wisconsin. I have given my reasons for referring these specimens to *radix*, but it must be admitted that they resemble *butleri* so closely as to be indistinguishable, and it may be that further material will show them to belong to this form and extend the range around the southern end of Lake Michigan, but the solution of the problem given on page 85 seems the most plausible one at present.

It is impossible with our imperfect knowledge of the limits of its range to point out any close relations between the distribution of

[a] As this paper is passing through the press I have received a specimen of *butleri* from Dayton, Ohio.

butleri and the conditions with which it is found associated. It must be acceded, in a general way, however, that, as far as our present knowledge goes, its range is apparently included in the area lying east of the prairie peninsula, which is characterized by the occurrence of open forests on the uplands (fig. 30). If, as I hope to be able to do, I can show that *butleri* is genetically related to *radix* this distribution may be easily accounted for by the fact that as *butleri* has prairie affinities, it might be expected to prefer conditions more in accord with those of the treeless region. I have already shown that the conditions in this region are somewhat intermediate between those of the prairie and the denser forests of southeastern United States, and, if a direct relationship exists between *butleri* and *radix*, the coincidence between the range of *butleri* and the open forest area may be accounted for by the affinities of both. This subject will be reverted to in discussing its affinities. It should be noted, however,

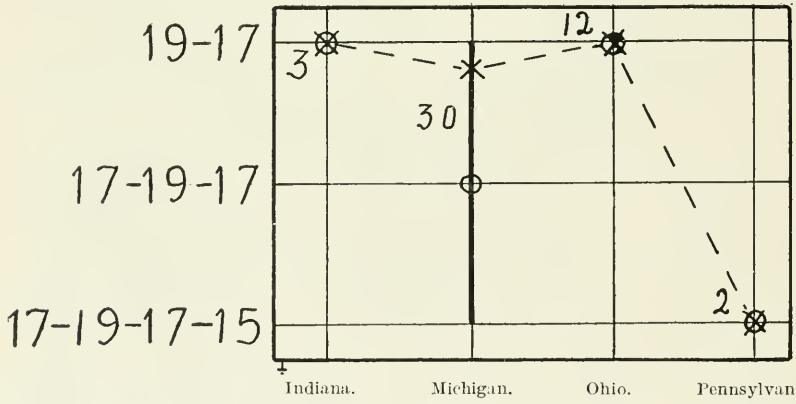

FIG. 31.—DIAGRAM SHOWING THE VARIATION IN THE DORSAL SCALE FORMULA IN THAMNOPHIS BUTLERI.

that the range of *butleri* is entirely within the glaciated area of eastern North America which would indicate that the form is of post-Glacial origin.

Variation.—The characters of *butleri* are quite constant and have not by their variability given rise to much confusion. The scale rows are invariably 19–17 in nearly all of the specimens examined, but it should be observed (fig. 31) that while a larger formula has never been observed, three of the Michigan specimens have the formula 17–19–17 and both of the Pennsylvania (*brachystoma*) specimens have 17–19–17–15, the smallest number observed. According to Cope, the type of *butleri* has 7 superior and 8 inferior labial plates, a formula that holds for the Lake Makinkuckee, Miami River, and Sandusky specimens (figs. 32 and 33). The Turkey Lake specimen has the same number, except on the right side, where one superior is dropped to leave 6. At Ann Arbor and Olivet, however, 6 supra-

labials occur in practically one-half of the specimens, and, while the infralabials are occasionally 8, 9, or 10, the average is very close to 8. The single specimen from Columbus has 6/8, the one from Frank-

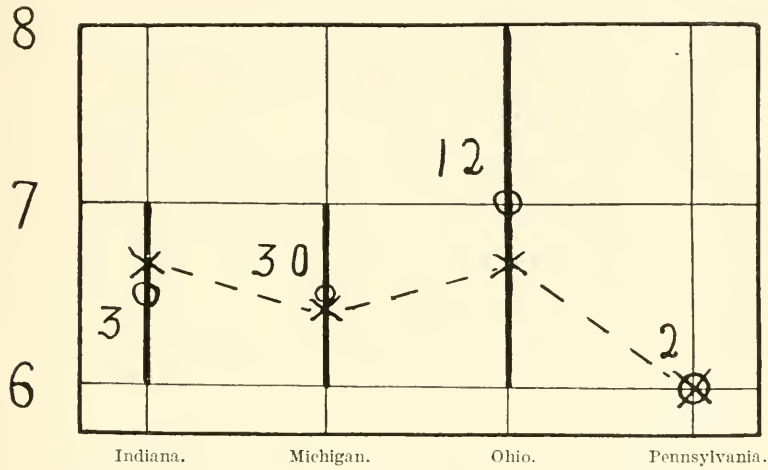

FIG. 32.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS BUTLERI.

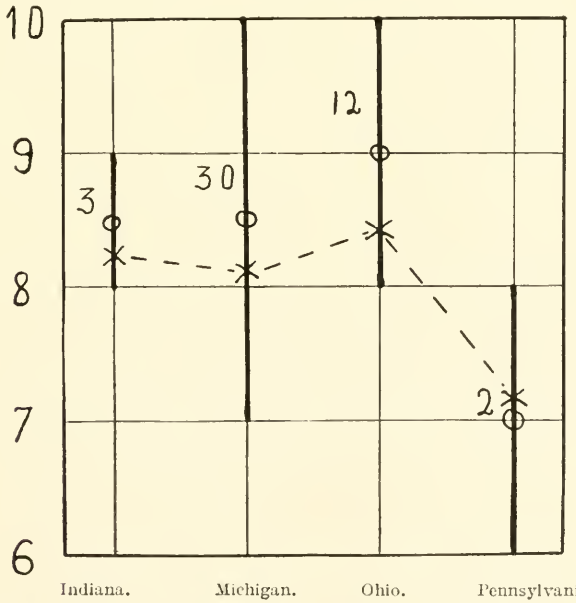

FIG. 33.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF INFRALABIALS IN THAMNOPHIS BUTLERI.

lin, Venango County, Pennsylvania has 6/8, and Mr. Fowler's specimen from McKean County, Pennsylvania, 6/6–7.

An examination of the ventrals shows the following distribution: Ann Arbor, males 134–146, females 132–140. All of the Indiana

and Ohio specimens fall within these extremes, as do also both of the Pennsylvania. Subcaudals (Ann Arbor, Michigan), males 61–66, females 49–58. The male records are based on but few specimens, however, and the number probably ranges both lower and higher. Indeed, a male from Columbus shows 59. The type of *brachystoma*, although doubtful, is probably a male and has 72. In the McKean County specimen the tail is injured. The series are too small to reveal geographic differences, if they exist.

One must be cautious in drawing conclusions from such a small amount of data, but the fact that in very few specimens west of Pennsylvania does the reduction in the dorsal scale formula become so low as in the Pennsylvania specimens nor the labial formula as small as in the McKean County specimen seems to us to indicate a reduction in scutellation to the eastward, at least as far as these characters are concerned. At any rate, it is evident, as is shown by the diagrams, that *butleri* as a form is characterized by a very reduced scutellation.

Affinities.—The only form with which *butleri* has been confused is *sirtalis*. Its distinctness from this form has been pointed out (Ruthven, 1904, 295 and 298), and this distinctness is such that there is slight reason for deriving it from this form, from which it differs in the position of the lateral stripe, the number of labial plates, and color, while lying entirely within its range. It also differs from *sauritus* in the number of labial plates and in the tail length, and also lies entirely within its range.

Here again the difficulty in establishing relationships lies in the fact that the position of the lateral stripe is noncommittal. It is true that posteriorly it is upon the second and third rows, but this is frequently the case in forms with the stripe on 3 and 4, when the fourth row is lost to leave 17 (*megalops* and *marcianus*). Anteriorly the lateral stripe is on 3 and one-half of 2 and 4, and it seems that this is probably due to a tendency to the loss of the fourth row, for where it is present the stripe is always partly upon it, while when it is absent the stripe is on 2 and 3. The only other form whose range it approaches is *radix*, and if the position of the lateral stripe be considered as a modification of the position which it occupies in this form (on the third and fourth rows), everything seems to point toward *radix* as the nearest relative; for, although *radix* has generally a larger scutellation, we have already seen that in the extreme eastern part of its range, which corresponds very closely with the western limit of *butleri*, a reduction occurs that brings the number of scale rows and labials, at least, exactly to the formulas that characterize *butleri*. I believe that I am justified in concluding, therefore, that this form is a member of the *Radix* group, and that its closest relative is *radix*, which it meets on the west.

CONCLUSION.

If the affinities of the different forms as indicated above (fig. 34) be accepted, this group, extending as it does from the Mexican plateau to the Great Lakes region, exhibits a progressive decrease in size and scutellation from the Mexican plateau toward the extreme limits of its range. The reduction is slight in each particular form, but when the extremes are compared with the center it becomes very apparent. Thus, *butleri* and *megalops* in northern Mexico are the extremes in the number of scales in each of the series which I believe to be correlated with size, while at the same time a slight knowledge of these forms is sufficient to show that there is also a striking difference in size between the two. It should also be noted that the areas in which the transitions from one set of scale formulas to another takes place

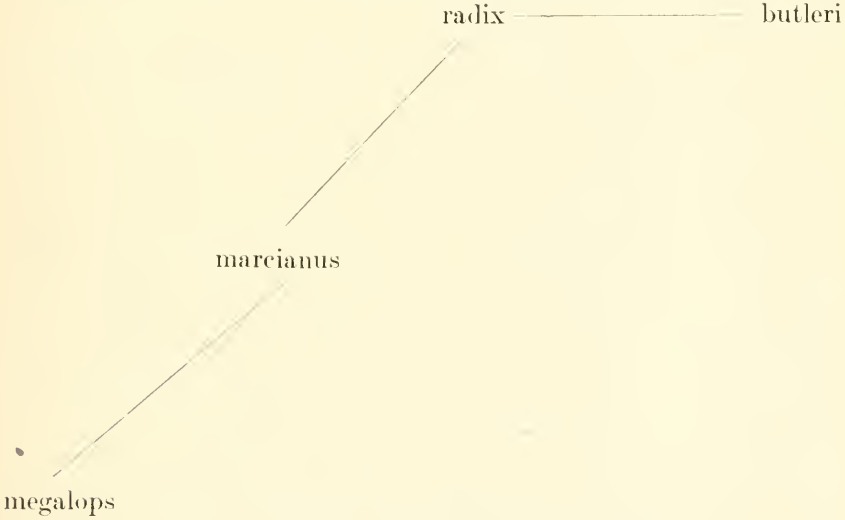

FIG. 34.—PHYLOGENETIC DEVELOPMENT OF THE RADIX GROUP.

lie mostly between the forms, and are apparently very narrow, except between *radix* and *butleri* since *radix* shows a marked tendency toward a reduced formula throughout the prairie region.

If the relationships are as I have described them, it should be noted (1) that in each region of different environmental conditions which it occupies the group is now represented by a different form; (2) that each form is characterized by a smaller scutellation than its neighbor toward northern Mexico, and exhibits its minimum scutellation at some point on the outskirts of its range, where it comes in contact with another form with the scutellation similar to that of the reduced individuals; (3) that the most dwarfed representative of the group is now found in the form farthest removed, geographically and genetically, from the northern part of Mexico.

THE SAURITUS GROUP. (PROXIMUS, SAURITUS, SACKENI.)

PROXIMUS.[a]

Description.—Contrary to most forms in the genus, there is little danger of confusing *proximus* with any other garter-snake. The stripe is always upon the third and fourth rows and the form is long and slender, the tail forming .25 to .37 of the total length. The dorsal scale rows are nearly always 19–17 (in the southern part of the range occasionally 17–19–17) and the labial formula is usually 8/10, only occasionally 8/9 or 8/11, and more rarely 7/10 or 7/9. The ventral scutes vary between 150–179 and the urosteges between 75–125.

In coloration *proximus* closely resembles the other forms of the group. The ground color varies from light olive to brown or black and is never broken up by distinct spots, although a narrow irregular black band is generally found along the stripes in specimens light enough to show it and many of the scales may have black edges and bases. In some of the paler specimens examined the usual two rows of alternating spots are distinct upon the skin, but in by far the majority of specimens these spots are fused more or less, so that the skin between the scales is usually black with numerous white lines irregularly disposed. The stripes may be of a bluish, yellowish, or greenish tint (the dorsal rarely reddish, occasionally brown), and the lateral is in every specimen examined upon the third and fourth rows; the dorsal usually occupies the median and the halves of the adjacent rows, but occasionally covers nearly all of the adjacent rows. The superior labials are always quite pale, occasionally reddish, in color and nearly always lack the black border that is found throughout all of the other groups. The ventral surface is generally bright yellowish, greenish, or bluish, and without or with very small and mostly concealed ventral spots.

Habits and habitat relations.—Very few records of observations upon the habits of this snake can be found. Under the name *Eutænia saurita* var. *faireyi*, Taylor (1892, 322) writes for Nebraska that the food "consists mostly of insects and their larvæ, but also includes fish, frogs, etc." Upon what authority this statement is made we do not know. In regard to three specimens taken at Progreso, Yucatan, Dr. L. J. Cole has written me as follows: "All of the specimens [three] were found in the water (brackish) in the mangrove swamps back of Progreso. One other specimen was seen, and that also was swimming in the water. I saw none of them on land." Cope says (1880, 23) that it is "like the *E. saurita*, aquatic in its habits."

[a] *Thamnophis sauritus proximus* (Say), Long's Exped. Rocky Mts., 1823, p. 187. Includes *Eutænia rutiloris* Cope and *E. faireyi* Baird and Girard.

By far the best account of the habits is that of Ditmars (1907, 220–221):

> In habits this snake appeals to the two preceding species [*sauritus* and *sackeni*]. It is very quick in its motions, and appears to be perfectly at home in the water, swimming with agility and extreme grace and diving to the bottom of a pond or stream and there secreting itself among aquatic plants.
>
> Captive specimens are very hardy, and will live indefinitely upon a diet of small frogs or fishes. A number of specimens in the writer's collection were very fond of climbing into a small branch that had been placed in their cage. Here they would coil in a tight cluster, with heads protruding in every direction. Upon the introduction of food they would dart for the prey in frenzied fashion, the lucky individuals thrashing their tails violently as if to distract the attention of their hungry associates from the morsels in the jaws of the former. One of these snakes gave birth to fifteen young on the 24th of August.

While our knowledge of its habits is thus very meager, from what is known of the other forms in this group I believe that, like them, *proximus* will be found to be more aquatic in its habits than most of the other forms of the genus.

Range.—Proximus is known to occur on the coastal plain from the eastern coast of British Honduras to the Mississippi River, and to the northward of this plain and west of the Mississippi River in the prairie-plains region and southeastern forest region of North America to about the latitude of the northern boundary of Iowa. The eastern coastal plain in Mexico is a low-lying tract of land bordering the Gulf of Mexico. The climate is hot and humid, the temperatures being tropical and the precipitation excessive. It is the "tierra caliente" of the Mexicans, and is characterized by a rich tropical flora that forms dense jungles. In Texas and Louisiana the coastal plain conditions are similar to those in Mexico. Extensive tide-washed, brackish marshes occur all along the coast, and are accompanied on higher ground by a biota of distinct tropical affinities (Bray, 1901, 102–103; Bailey, 1905, 16–18).

The prairie region of North America has been briefly described. The southeastern forest region, which occupies southeastern United States south and east of the prairie region, is characterized by being the principal area of development of the hard-wood forest; it is the home of *Quercus alba*, *Magnolia acuminata*, *Acer saccharum*, *Fagus americana*, *Liriodendron tulipifera*, *Fraxinus americana*, *Quercus rubra*, and *Hicoria alba*. Transeau (1905) has shown that the region is characterized by a rainfall evaporation ratio of 100–110 per cent and that where this ratio falls to 80–100 per cent the flora merges into that of the prairie region. The southeastern forest region to the south of the prairie peninsula crosses the Mississippi and extends to the eastern limit of the prairie, which, as previously stated, is the western edge of the Ozark highlands and the 98th meridian. *Proximus* enters this region, then, only in its western part.

Specimens of *proximus* with definite locality data have been examined as follows: Progreso and Cozumel Island, Yucatan; Orizaba, Xalapa, and Tuxpam, Veracruz; Matamoras, Tamaulipas; Caderita, Neuvo Leon; Tule Canyon, Dallas, Matagordo, Pecos, Fort Cobb, Brownsville, Wheelock, Helotes, New Braunfels, Austin, Kerrville, San Pedro, San Angelo, Fort McKavett, Devils River, High Bridge, Pecos River, and Fort Stockton, Texas; New Orleans, St. James Parish, Belair, Slidell, Prairie Mer Rouge, Calcasieu Pass, Perry, and Grand Coteau, Louisiana; Greenway, Arkansas; Butler County, Montgomery County, St. Clair County, St. Louis, Missouri; Neosho Falls and Dora, Kansas; Nemaha County, Nebraska; Ames and Des Moines, Iowa; Chicago, Rock Island, Olney, and Mount Carmel, Illinois; Fox River and Racine, Wisconsin.

Boulenger (1893, 214) records specimens from Belize, Honduras.[a] Bailey (1905, 48) gives the following Texas localities: "Brownsville, Lomita Ranch (Hidalgo County), Sycamore Creek, Corpus Christi, and San Antonio River, near San Antonio." Taylor states that he has examined specimens from Nemaha, Saline, and Saunders counties, Nebraska. Branson writes that in Kansas he examined specimens from "Wallace, Douglas, Franklin, Geary, Woodson, Clark, and Shawnee counties." At present we consider all of the Illinois and Wisconsin ribbon snakes as belonging to this form, but, as later stated, more evidence may show that the specimens in this region are not typical. Ribbon snakes occur throughout the former State,[b] and in Wisconsin at least to Racine, and probably farther north, for a single specimen in the U. S. National Museum (No. 731) is labeled "Fox River." No definite Minnesota record has been found, the only record being a single specimen (No. 6179) in the Academy of Natural Sciences of Philadelphia, labeled "Minnesota."

The distribution of this form (fig. 35) is thus in harmony with its aquatic habits. In Mexico it is confined to the coastal plain, being apparently unable to push out from this area. In eastern Texas, however, it encounters the eastern forest, which, as would be expected, apparently furnishes conditions somewhat similar to those of the coastal plain and permits the form to extend its range throughout this environment west of the Mississippi, and even to extend entirely across the prairie region and into the great plains and northeastern forest regions along the streams. Detailed evidence is not at hand that *proximus* is confined to the vicinity of streams in the prairie

[a] Boulenger (1893, 213) also records a specimen from the Atoyac River, Guerrero, and Günther (1894, 132) gives the locality Guatemala, but as these localities are the only ones outside of the eastern coastal plain of Middle America, the data and identification of the specimens should be ascertained with certainty before the range is extended to include them.

[b] H. Garman (1892, 265) gives the following Illinois localities: Chicago, Cook County; Peoria, Normal, Jersey County; Mount Carmel, Union County.

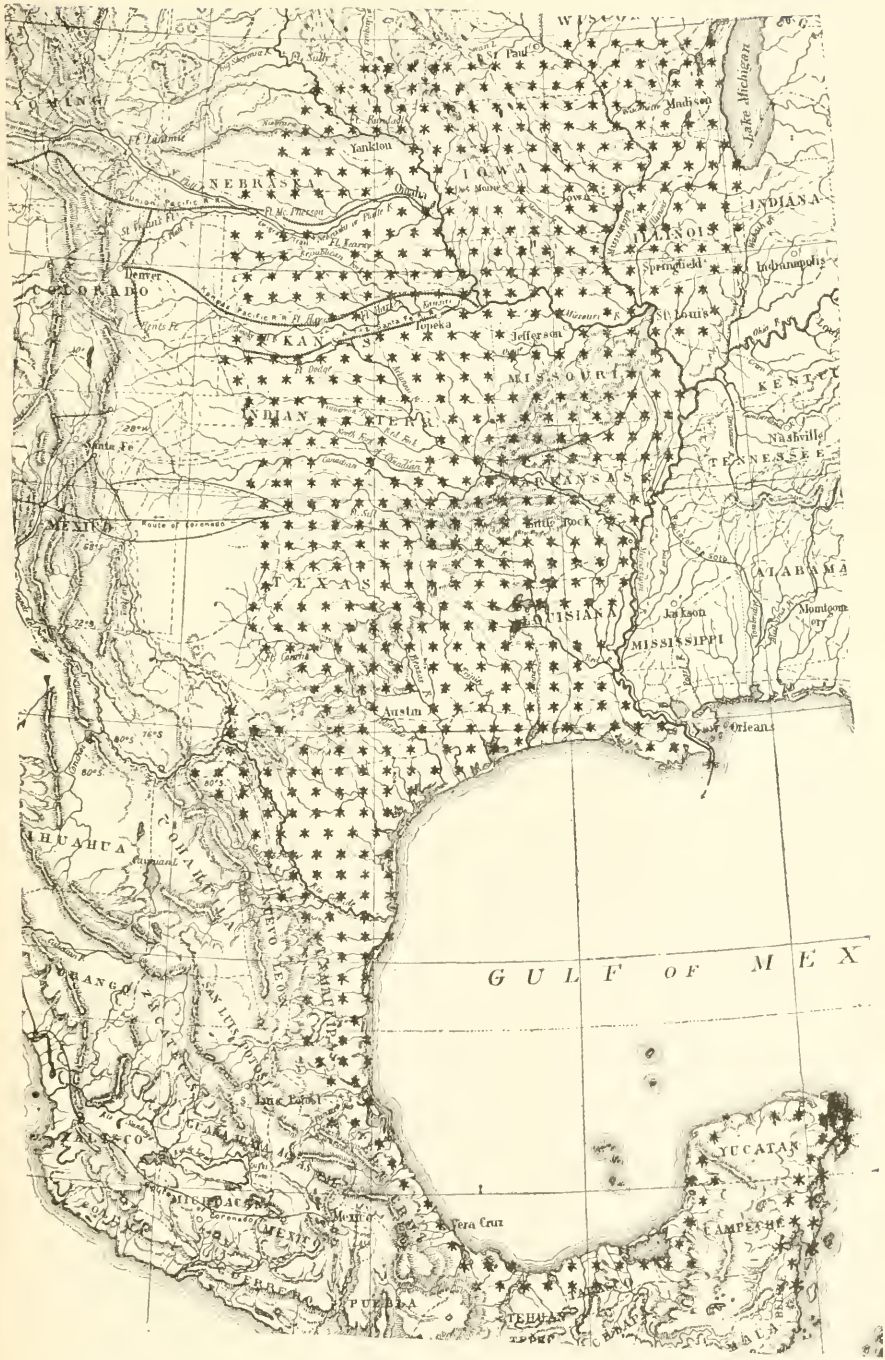

FIG. 35.—DISTRIBUTION OF THAMNOPHIS SAURITUS PROXIMUS, AS INDICATED BY THE LOCALITY RECORDS.

region, but it is significant that the records in the plains region of Texas are all on rivers that flow eastward into the Gulf of Mexico, while the Kansas, Nebraska, and Iowa records are all in the vicinity of tributaries of the Mississippi. This does not prove conclusively that the form only occurs along streams in the grass-land regions, but since, I believe, it will generally be found closely associated with aquatic habitats even in the more humid and forested parts of its range, it would be surprising if it had a wider distribution in the more arid and treeless parts of the region in which it occurs.

Variation.—Proximus exhibits such stability in most of its characters that it should be comparatively easy to detect the nature of such differences as do occur. The number of scale rows is invariably 19–17 throughout the greater part of its range. Indeed, I have observed but a single specimen with a different formula, a specimen (No. 755) from Orizaba, Veracruz, in the U. S. National Museum, which has 17–19–17. It should be noted that this locality is toward the southern limit of the known range of the form.

While the superior labials are somewhat more variable (fig. 36), the variations are still slight. The only variations observed are one

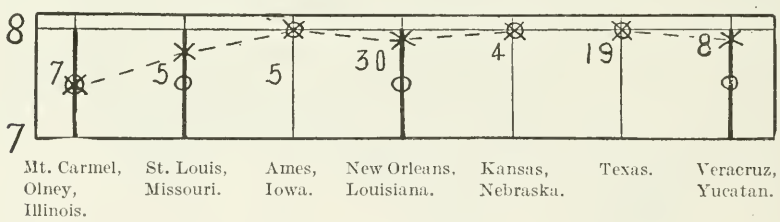

FIG. 36.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS SAURITUS PROXIMUS.

specimen from Progreso, Yucatan, and two from New Orleans, with 7 on both sides, and one with 7–8 from Belair, Louisiana, one specimen with 7 from St. Louis, Missouri, one with 7–8 and one with 7 from Olney, Illinois, and two with 7 and one with 7–8 from Mount Carmel, Illinois. These are slight variations, but it is significant that the tendency toward a decrease is only shown near the eastern and southern limits of the range. In the case of the number of dorsal scale rows and supralabials the variations are in all cases in the nature of a reduction. In the number of inferior labials, however, we find both an increase and decrease from the usual number, 10. The only two variations observed are 9 and 11, and these occur so rarely and so generally throughout the range that much larger series must be examined before we can hope to detect any geographic differences in this character.

I have stated that *proximus* has from 150–179 ventral plates. It is with reluctance that I give the table below (fig. 37), for I have not enough specimens to plot the sexes in equal proportions and have

had to base my averages upon all of the specimens available, and I am well aware that the sexual variation is sufficient to render the averages very deceptive in such small series. If care is taken, however, not to attach too much importance to the averages, I believe that the table indicates very plainly that the number of ventral plates is quite constant over the North American portion of the range, and that from the State of Veracruz southward, in Mexico, there is a decrease in the number of scales in this series. This decrease in the southern part of the range is shown not only by averages from the different localities, but also by the fact that the smallest number of ventral plates observed in one hundred specimens examined from the United States is 158 (which occurs in but two specimens from New Orleans), while both specimens from Yucatan, in which the scales

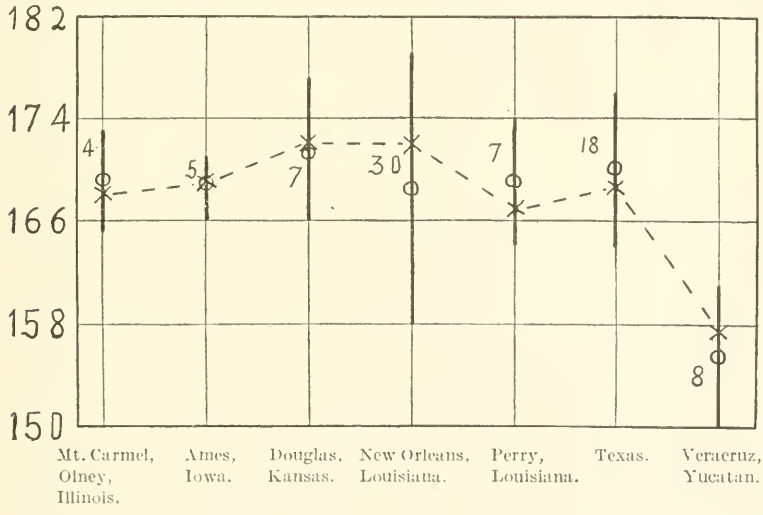

FIG. 37.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF VENTRAL SCUTES IN THAMNOPHIS SAURITUS PROXIMUS.

have been counted, is as low as 150. Further than this the maximum number for six specimens from the State of Veracruz is 161, which is lower than any number observed in the United States, with the exception of the two New Orleans specimens. I readily grant that the series of specimens examined is too small to furnish exact evidence of the amount of decrease, but I believe that the records do indicate plainly that a reduction in the number of ventral plates actually takes place in southern Mexico. There is no evidence, however, of a decrease in the number of plates in this series toward the eastern part of the range, comparable to that shown by the supralabials.

As before mentioned the tail in *proximus* is comparatively long; the proportionate length observed varies from .25–.37. Although this variation is considerable, the extremes are seldom reached and the mean length of tail is about .29 or .30 throughout the range.

There is thus no geographical variation shown conclusively in the averages, but it should be noted that the longest tails are found in Louisiana, which may indicate a tendency toward an increase in the length of this organ in this region (fig. 38), while the shortest tails occur in Texas.

Less evidence is at hand regarding the number of subcaudal scutes than is the case in any other series of scales, largely owing to the fact that the tail of many specimens is broken. The extremes are 75–125, an extent of variation which is equaled in no other form in the genus. The averages are not to be relied upon, but it may be seen from the table (fig. 39) that the smallest number occurs in the southwestern part of the range and the largest number in Louisiana. In this case, however, the variation in the number of subcaudal scutes is apparently associated with a variation in the tail length and affords no evidence of the dwarfing shown by the other characters.

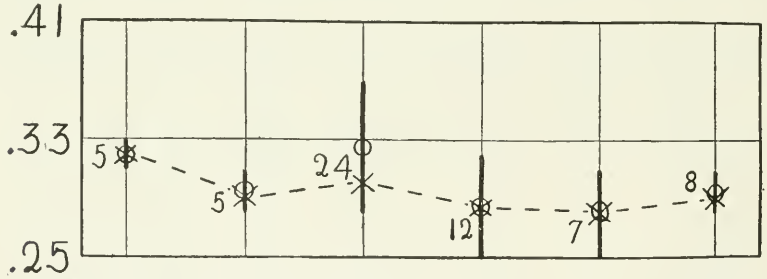

FIG. 38.—DIAGRAM SHOWING THE VARIATION IN THE PROPORTIONATE TAIL LENGTH IN THAMNOPHIS SAURITUS PROXIMUS.

There are few variations in coloration that deserve mention. Occasionally the dorsal stripe is red, but how frequently we do not know, since this color rapidly disappears in alcohol. Occasionally, also, this stripe becomes somewhat obscure, but both of these characters are apparently liable to crop out almost anywhere in the range. The type of *Eutænia rutiloris* Cope is characterized by this obscurity of the dorsal stripe, although the latter is visible throughout the entire length of the body. The only other character (and the principal one) upon which this form was based was the presence of red upon the "superior and inferior labial plates and the first three large gastrosteges." This color is now faded and I have never observed a specimen of *proximus* which exhibited it, but the specimen differs in no other way from the Yucatan specimens of *proximus*, and the character is of too little importance to justify the separation of this specimen from *proximus* (See Ruthven, 1906a).

To summarize the variations in *proximus:*

(1) The dorsal scale formula is 19–17 throughout the range, except in southern Mexico, where a specimen with 17–19–17 has been examined.

(2) The superior labials are 8 over most of the range, 7 only being observed in Yucatan and in general along the Mississippi River.

(3) The inferior labials are usually 10, occasionally 9 or 11, but the variations are so evenly distributed over the range that no geographic differences can be detected in the small series examined.

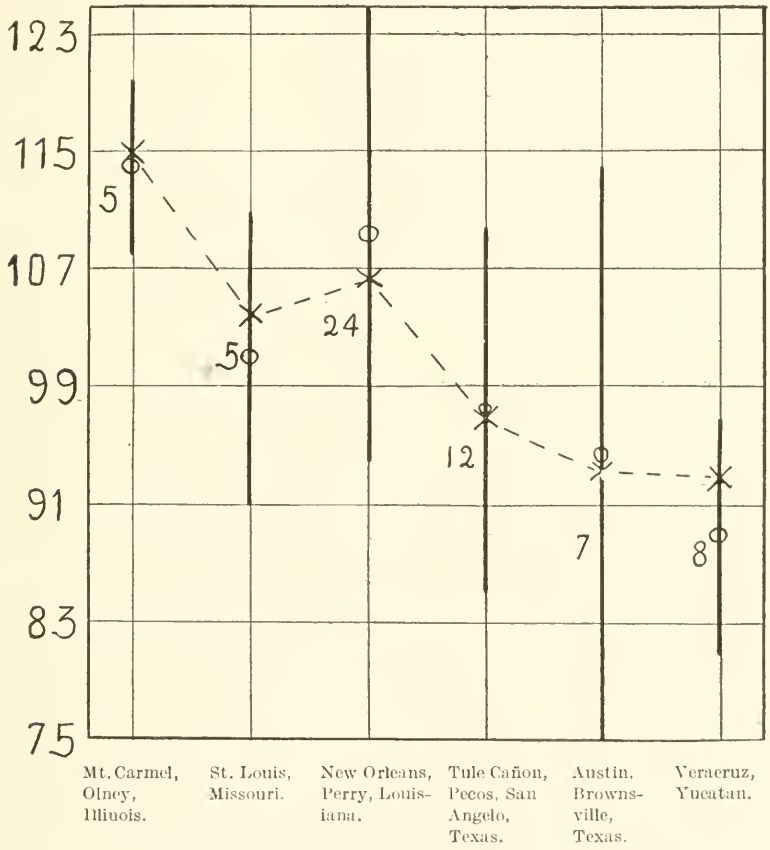

FIG. 39.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUBCAUDAL SCUTES IN THAMNOPHIS SAURITUS PROXIMUS.

(4) The variation in the number of ventral scales is large (150–179), so that from the small amount of material available little reliance can be placed on the averages, but the number (both the averages, maximum and minimum) is strikingly smaller in Veracruz and Yucatan specimens than in the series from North America.

(5) The tail length is very variable, although the mean length for the different localities is quite constant. Southwestern specimens

have the lowest number and Louisiana specimens the highest, which may indicate a tendency toward an increase in tail length in the latter region.

(6) The number of subcaudals as it is correlated with the tail length is variable, so that the averages in the small series are not to be depended upon. But the largest number occurs in Louisiana and the lowest in the southwestern part of the range in harmony with the variations in tail length. Owing to the correlation of the two, the variation in the latter obscures any tendencies toward dwarfing that may exist.

(7) The color variations are too slight to permit of the formation of any geographic races on this basis.

If, then, our material can be relied upon, there is indicated a tendency toward a decreased number of dorsal scale rows and ventral plates in southern Mexico and a decreased number of supralabials in general along the Mississippi River, which if true may be considered as an evidence of dwarfing in *proximus* in these two extremities of the range, while there is an apparent increase in the tail length in Louisiana, as shown by measurements and the number of subcaudal scutes.

Affinities.—If we admit the evidence of the position of the lateral stripe, *proximus* is closely allied to *sauritus*, *sackeni*, and the members of the *Radix* group. Its relation to *sauritus* and *sackeni* is very close, as will be shown later; but its affinities with the *Radix* group are less clear. The chief character which separates it from this group is the decidedly longer tail; but, as shown above, the length of tail decreases in the southwestern part of the range, thus lessening the distinctive value of this character. It is in this region, therefore, that the form most closely resembles the forms of the *Radix* group, and it is here where the closest affinities must be sought. In northern Mexico and western Texas it differs markedly in scutellation from the representatives of the *Radix* group (*megalops* and *marcianus*) only in the smaller number of scale rows (19–17 instead of 21–19–17). This difference, as already seen, is only of racial importance, and as the formula is but one step less than that of the *Radix* group in this region, there can be no objections on this score to the direct deviation of *proximus* from *marcianus* or *megalops*. On the other hand, the range of *proximus* overlaps the range of *marcianus* to a considerable extent without effecting the distinctiveness of either type, which argues against a direct relationship between the two forms, and the same is true of *radix*.

Concerning *megalops*, however, the case is different. The ranges of the two forms come close together in Mexico, but do not overlap, *megalops* inhabiting the plateau and *proximus* the coastal plain. The tail length in *proximus* is also less different from *megalops* than

from any other form in the *Radix* group, both owing to the somewhat greater length of tail in *megalops* and to the shorter tail in *proximus* in northern Mexico. Since the scutellation is practically the same in the two forms, except that the dorsal scale formula in *proximus* is slightly smaller, it may be that *proximus* is a direct relative of *megalops* which has pushed eastward into the eastern coastal-plain region of northern Mexico, and from here southward and northward into the regions which it now occupies. However, it is quite distinct from *megalops* at the present time, in the long tail and more slender body, and it is to the northward that we must look for its closest relatives.

SACKENI.[a]

Description.—This beautiful snake has received but little attention from herpetologists and is represented in collections by but few specimens. The scutellation may be defined as follows: Dorsal scale rows, 19–17; supralabials, 8; infralabials, 10; ventral plates, 154–171; subcaudal scutes, 109–134; tail length, .32–.38. The coloration is similar to light specimens of *proximus*, the lateral stripe being on the third and fourth rows (yellowish or greenish), the ground color usually a shade of brownish olive, and the belly and labials light and generally unmarked. As in *proximus*, the ventral spots are usually absent, but not always, and the lateral spots are generally fused irregularly, although occasionally distinct in the usual two rows between the stripes; even when distinct on the skin, however, they are not represented on the scales except by a narrow black border along the dorsal, and occasionally the lateral stripes. The lateral stripe is always distinct, but the dorsal is generally obscure and often entirely wanting; when present, it covers all or nearly all of the median three rows.

Habits and habitat relations.—*Sackeni* is a very interesting snake. In the length of tail and slender body it represents the extreme in the group and genus, and with the attenuated form is coupled an agility of movement that we doubt is exceeded in any other garter-snake. While comparatively little is written upon its habits, there is slight doubt but that, like *proximus*, *sackeni* is quite aquatic in its habits. Thus, Ditmars (1907, 219–220) writes, "In habits this species is very similar to the ribbon snake [*sauritus*]. It is very aquatic, and is seen frequently sunning on the branches of bushes that overhang the water, into which it drops when alarmed." Loennberg (1894, 329) remarks of the specimens obtained by him in Florida, "All were caught in the grass in wet places." Personally I have been able to make few observations on the habits of this form. During the summer of 1905 I reared two broods which were born on July 19. The young resembled those of other forms in habits except for

[a] *Thamnophis sauritus sackeni* (KENNICOTT), Proc. Acad. Nat. Sci. Phila., 1859, p. 98.

their greater agility. Like the adults, they steadily refused earthworms, but at the age of three days took to the water and captured and ate live minnows voraciously. Their manner of catching fish was interesting. Dropping or climbing into the basin they would rush about, mouth open, until they encountered a fish, when they would rush out of the water, lashing their tails energetically, carry the fish to a corner and proceed to devour it. The sense of sight seemed to be depended upon but little in capturing fish, and dead ones were eaten apparently as frequently as live ones.

Range.—As at present known the range of *sackeni* is confined to the southern part of the coastal plain, in southern Mississippi and Florida. This physically recent feature with its low altitude (nowhere more than a few hundred feet above sea level) is characterized by scores of stagnant rivers, lakes, lagoons, and swamps. The temperature and humidity are high and the rainfall-evaporation ratio exceeds 110 per cent (Transeau, 1905). The vegetation is rich, and consists of such forms as white cedar, sweet bay, magnolia, tupelo gum, swamp cottonwood, cypress, *Quercus texana*, etc., in the swamps, and several species of pines on the higher ground.

Specimens of true *sackeni* have been examined from the following localities: St. Johns River, Volusia County, Georgiana, Palatka, Orange Hammock, Kissimee River, Kissimee, Enterprise, Lemon City, Little Sarasota Bay, Clear Water, Pensacola, Marion County, Gainesville, and Orlando, Florida, and Bay St. Louis, Mississippi. As far as I have been able to find, the form has never been recorded outside of Florida, although Ditmars (1907, 219) states that it is distributed in the "coast regions of South Carolina and Georgia; Florida generally." Certainly typical *sackeni* may be expected to occur somewhat north of the latitude of the northern boundary of Florida, but in this general region it comes in contact with *sauritus* and the status of the two forms in the intermediate region must be examined before the northern boundary of *sackeni* can be even approximately fixed. I must confess to have examined but very few specimens from the debatable region, but the fact that *sauritus* specimens from the coastal plain from North Carolina northward show a much closer affinity to *sackeni* than those from central Alabama would seem to indicate that true *sackeni* pushes farther up the Atlantic coast than in the interior, possibly into Georgia and South Carolina, as Ditmars indicates, which might also be expected in view of its more aquatic habits and its association with the coastal plain conditions throughout the greater part of its range. The range as known at present is indicated on the accompanying map (fig. 40).

Variation.—The dorsal scale formula is easily disposed of, for in every specimen examined it is 19–17. The labial formula is nearly

as constant, although the diagram (fig. 41) indicates that there is some variation in the number of superior labials. Thus, while 8 supralabials is the rule throughout most of the range, 7 occurs in the

FIG. 40.—DISTRIBUTION OF THAMNOPHIS SAURITUS SACKENI, AS INDICATED BY THE LOCALITY RECORDS.

western (southern Mississippi and western Florida) specimens, although in what proportion it is impossible to estimate, as very little material is available from this region. The inferior labials are 10 in

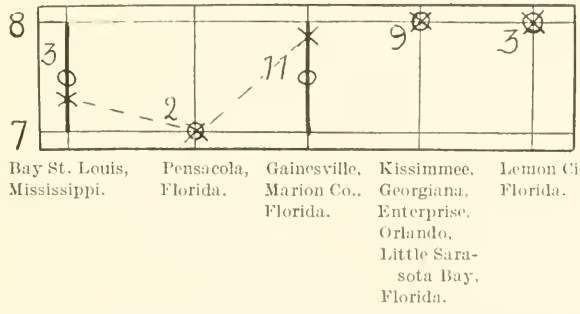

FIG. 41.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS SAURITUS SACKENI.

every individual examined. The number of ventral plates is rather variable (fig. 42). The extremes are 154–171, the average number lying between 158–166. There is no definite geographic variation in

this trait indicated by the material examined. The tail length is strikingly constant for this group, which may be in part but not entirely explained by the small amount of material; the length exceeds that of any other form in the genus, the extremes being .32–.38, the average between .33–.36 (see fig. 43). As is to be expected from

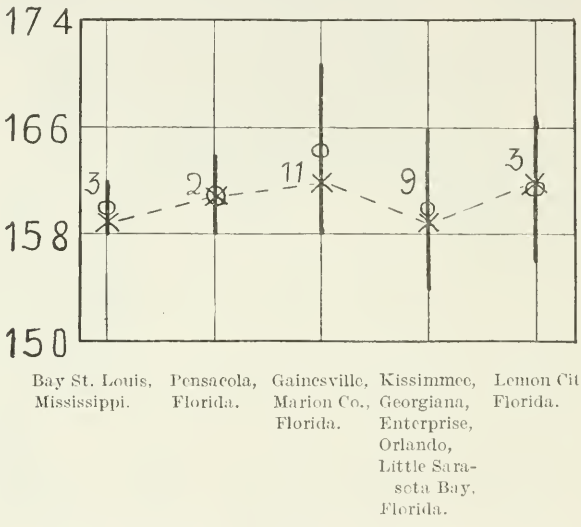

FIG. 42.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF VENTRAL SCUTES IN THAMNOPHIS SAURITUS SACKENI.

the length of the tail, the number of subcaudal scutes also exceeds that of any other form. As shown by the diagram (fig. 44), the extremes are 109–134 and the averages for the different localities

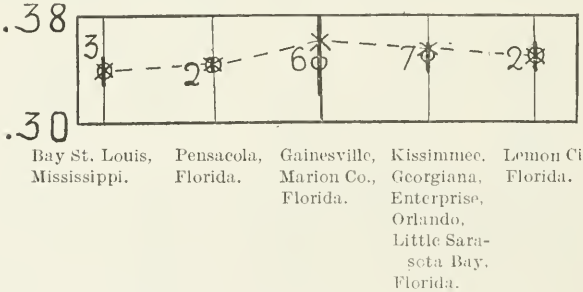

FIG. 43.—DIAGRAM SHOWING THE VARIATION IN THE PROPORTIONATE TAIL LENGTH IN THAMNOPHIS SAURITUS SACKENI.

between 120 and 127. Here again no geographic variations can be detected.

As is generally the case in the forms of the *Sauritus* group, there is little variation in coloration in *sackeni*. The usual variation of light to dark in the ground color is present, the lighter individuals being a

light greenish olive, the darker ones often dark brown. The lateral stripe is always present, but, as stated above, the dorsal stripe is usually obscure. Still, although *sackeni* is usually described as having the dorsal stripe obscure or wanting, this is decidedly not always the case, for in some of the specimens in the U. S. National Museum from Georgiana, Florida, it is not only well defined but also of a bright color. This variation is not geographic, but may occur in individuals apparently anywhere in the range.

Affinities.—Fortunately there is little difficulty in determining the affinities of this form. The position of the lateral stripe on the third and fourth rows and the length of tail at once proclaims it a member

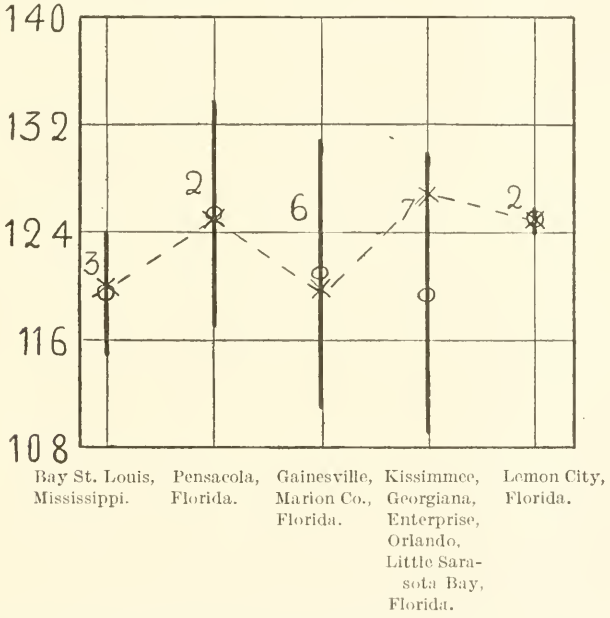

FIG. 44.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUBCAUDAL SCUTES IN THAMNOPHIS SAURITUS SACKENI.

of the *Sauritus* group. It differs from *proximus* only in the greater average length of tail and the consequent larger number of subcaudal scutes, a smaller number of ventral plates, and the frequent obscurity of the dorsal stripe. A knowledge of the variations, however, shows that these differences are slight, for (1) the dorsal stripe in *proximus* is occasionally obscure, (2) the length of tail and number of subcaudal scutes in *proximus* apparently increases, while the number of ventral plates decreases in southern Louisiana to approximate the condition in *sackeni*. As a matter of fact there is no reason to believe that the two forms do not intergrade perfectly in southern Mississippi. It should be borne in mind, however, that although *sackeni* has a longer tail and more subcaudal scutes than *proximus* it apparently

tends to be more dwarfed, as shown by the reduced number of ventral plates and possibly by a tendency toward 7 instead of 8 superior labials. Its relation to *sauritus* will be considered later.

SAURITUS.[a]

Description.—This is the best and longest known form in the group. The lateral stripe is upon the third and fourth rows throughout the length of body. The tail is longer than in *proximus*, but not as long as in *sackeni*, the length varying from .29 to .36. The scutellation may be described as follows: 19–17 dorsal scale rows; 7, occasionally 6 or 8, superior labials; 10, occasionally 9, rarely 11, inferior labials; ventral plates, 150 to 172; subcaudal scutes, 87–137. The ground color above is usually chocolate brown, but varies from light olive brown to black. Michigan specimens are quite frequently black, with the exception of the keels of the scales, which are light brown. The stripes are nearly always bright and conspicuous, the dorsal generally having an orange tint, the laterals paler and of a greenish cast. The labials are usually without black blotches and the lateral spots are seldom distinct, although they are not always entirely fused to the total abolition of the light (whitish) interspaces. As in *proximus* and *sackeni*, the ventral spots are generally absent.

Habits and habitat relations.—Like the other members of the group, *sauritus* seems to be more than ordinarily aquatic in its habits, but apparently less so than either *proximus* or *sackeni*. In Michigan we have generally found it about the margin of ponds and streams in damp woods. It is somewhat of a climber, and is occasionally found in bushes, several feet from the ground. When pursued it glides through the pools and herbage at an astonishing rate, and does not hesitate to take to water and conceal itself among the water plants, but it generally remains near the surface, and we have never observed it dive to the bottom like a natricid snake. There are numerous short notes in the literature, to the effect that *sauritus* prefers damp situations.

Ditmars (1907, 217–219) states that it feeds on salamanders, tadpoles, frogs, and fish, but, like *sackeni*, refuses earthworms. Two other writers, Atkinson (1901, 151) and Surface (1906, 142–143), record insects in stomachs examined. The latter gives the following as making up the stomach contents of Pennsylvania specimens: Earthworms, spiders, insect fragments, ants, *Plethodon cinereus*, *Spelerpes bilineatus*, *Hyla versicolor*. It should be noted that the insects may have been contained in the stomachs of the frogs and salamanders. The number of young is comparatively small; we have counted the embryos in a few specimens, and they seem to average about a dozen.

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[a] *Thamnophis sauritus* (Linnæus), Syst. Natur., XII, p. 385.

Range.—As is well known, *sauritus* is found in the forest region of eastern United States. Characterized by mild temperatures and a plentiful rainfall, this region supports an abundant arboreal vegetation that extends to the northward to the limit of tree growth and to the westward to the prairies. It includes two types of biota, the northeastern conifer, and southeastern deciduous forest types. The northeastern coniferous forest is characterized by such trees as the larch, balsam, white and black spruce, white and red pine, etc., and centers in the Laurentian highlands, while the southeastern deciduous forest type possesses the sugar maple, white ash, beech, and several oaks, and centers about the southern Appalachians. These two types of biota intergrade for a considerable distance in Michigan, New York, New Hampshire, and Vermont, although the higher parts of the Appalachians carry an outlying tongue of the northeastern coniferous type as far south as Georgia. The deciduous forest reaches its greatest development in southeastern United States and, as already noted, grades into the prairie through the so-called "fringe forest," which covers all of Ohio and Indiana, and margins the prairie in Illinois, Missouri, southeastern Kansas, and east-central Texas.

Specimens of *sauritus* have been examined from the following localities: Roscommon County, Alma, Olivet, Washtenaw County, Lapeer County, Rawson Lake, and Lansing, Michigan; Waterloo, Lake Maxinkuckee, Veedersburgh, Lebanon, and Wheatland, Indiana; Medina County, Toledo, and Oberlin, Ohio; Delaware County, Darby, Londongrove, Allegheny County, Carlisle, and Indiana County, Pennsylvania; Haddonfield and Pleasant Point, New Jersey; Tioga County and Highland Falls, New York; Middletown, Connecticut; Wellesley, Sherborn, Woods Hole, and Lancaster, Massachusetts; Auburn, Maine; Chepachet Island, Rhode Island; Arlington, Virginia; Laurel, Maryland; Washington, District of Columbia; Avoca, Summerville, and Wilmington, North Carolina.

These localities represent the entire range of the form, as at present known, and it is not necessary to cite the numerous records in the literature. From these records it is evident that, if the form is properly defined, the range is closely confined to the southeastern forest region, north of Florida and east of the Mississippi River and the prairie peninsula. The northernmost localities known to me are Roscommon County, Michigan, Norway and Auburn, Maine, which would indicate, as is undoubtedly the case, that the form occurs in extreme southern Canada. It will thus be seen that *sauritus* does not enter the northeastern forest proper, but pushes well into the intermediate region between this forest and that of southeastern North America.

The western and southern limits are not definitely known. This is due in large part to the want of specimens from the region of these boundaries. As will be shown later, however, the western limit may probably be given in general as the Indiana-Illinois boundary and western Kentucky, Tennessee, and Mississippi (fig. 45).

Variation.—From the list of localities from which specimens of *sauritus* have been examined it might seem that a considerable amount

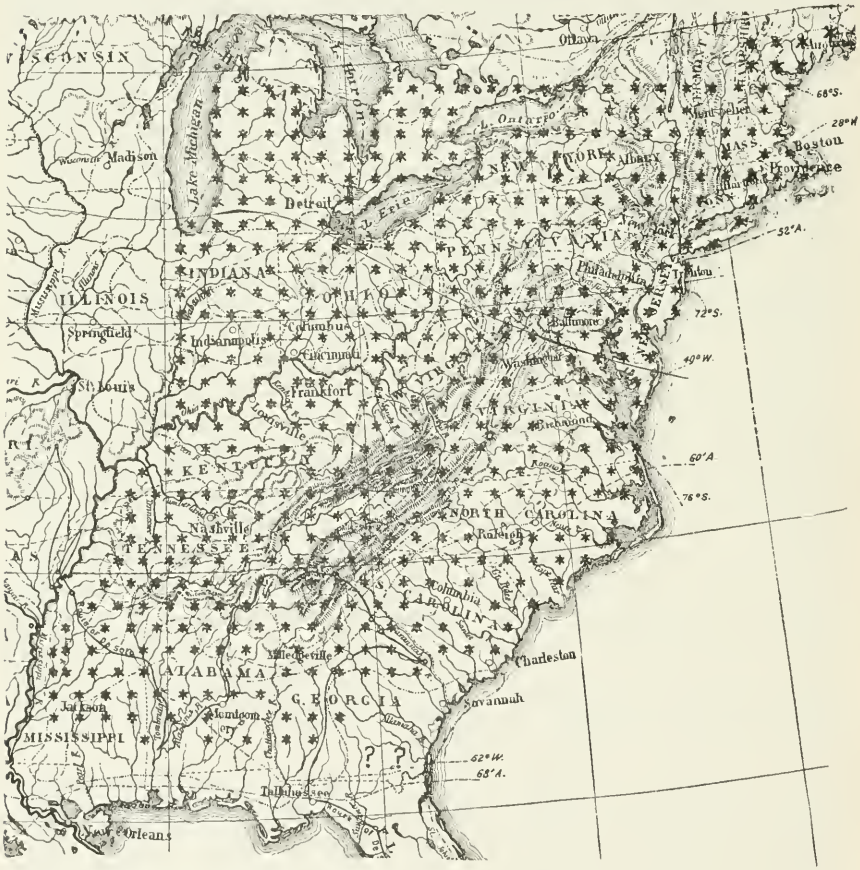

FIG. 45.—DISTRIBUTION OF THAMNOPHIS SAURITUS, AS INDICATED BY THE LOCALITY RECORDS.

of material was available for the study of this form. Unfortunately, however, none of these localities are represented by more than about a dozen specimens, the usual number being one to four. Even after combining the records from neighboring localities, the data is still insufficient to denote more than general conditions.

As in the case of *sackeni*, the dorsal scale formula in no specimen examined departs from 19–17.[a] The labial formula, on the other

[a] Compare p. 35.

hand, is more variable than in either of the other forms in the group. An examination of the diagrams (figs. 46–47) will show that the variation in both series consists of a loss or an addition of one scute from the more constant number 7/10. The average number of supralabials is generally a little above 7, showing the comparative

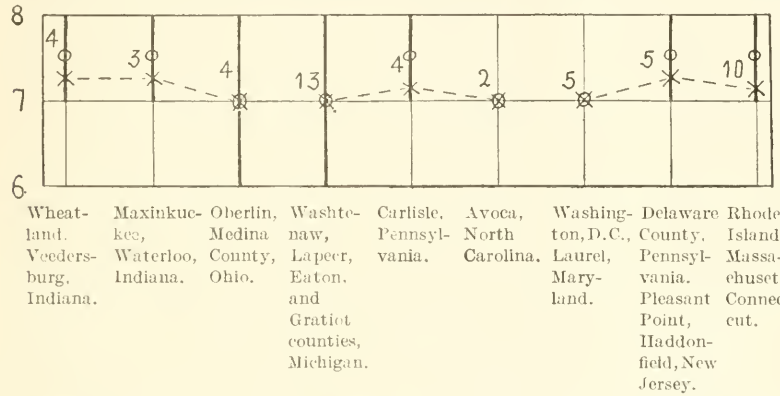

FIG. 46.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS SAURITUS.

rareness of specimens with 8 or 6 scutes in this series. No definite geographic differences can be discovered in the material examined. In the case of the infralabials the conditions are exactly reversed in that, while the variations are so slight as to disturb the averages

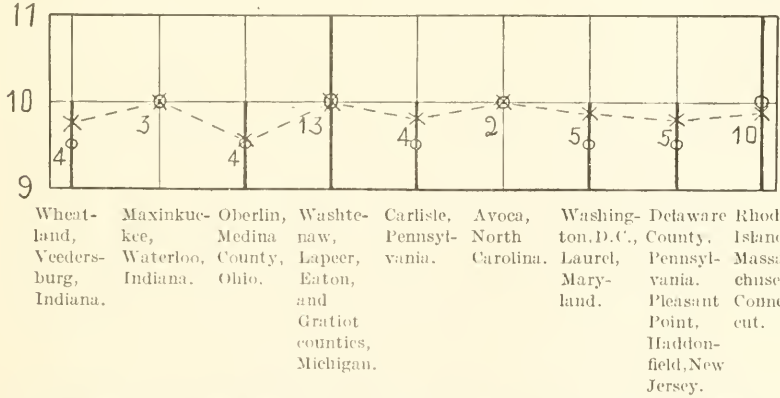

FIG. 47.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF INFRALABIALS IN THAMNOPHIS SAURITUS.

but little, the differences that do occur are mostly by way of a reduction to 9, so that the averages run a little below 10.

As in the other ribbon snakes, the variation in the number of ventral plates is considerable. In the material examined the extremes are 150 and 172. The table (fig. 48) will show how the

variations are distributed. While this diagram is very subject to error, owing to the small number of specimens, it is interesting to note that specimens from eastern localities have apparently a smaller number of ventral scutes than those from Michigan, Ohio, and Indiana, and while larger suites of specimens will undoubtedly

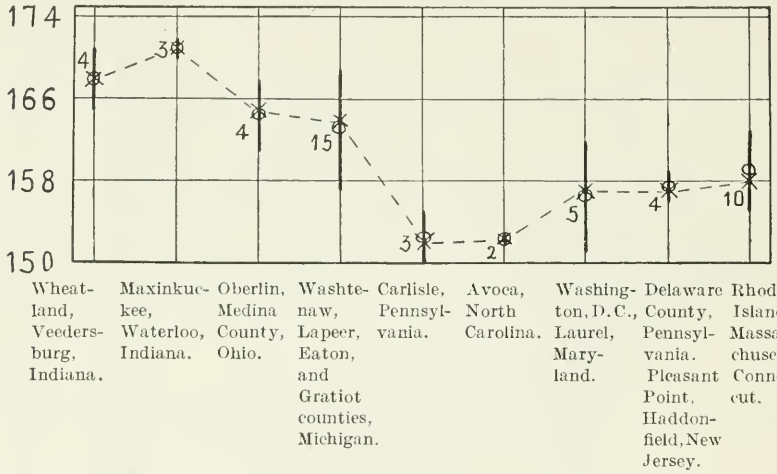

FIG. 48.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF VENTRAL SCUTES IN THAMNOPHIS SAURITUS.

change the averages, we believe that the difference is a real one. The length of tail (fig. 49) is apparently quite constant. The extremes are .29 to .36, the average about .33, and while the average can not be relied upon, it may be significant that the tail length is

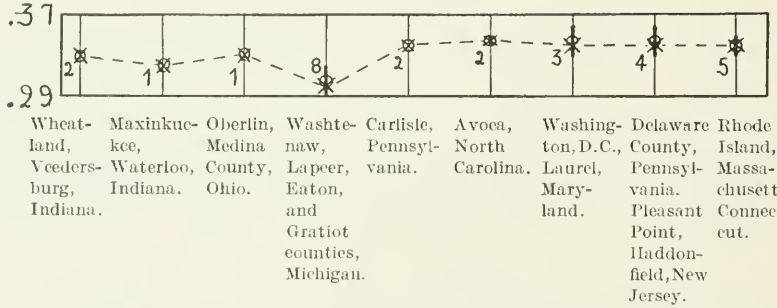

FIG. 49. DIAGRAM SHOWING THE VARIATION IN THE PROPORTIONATE TAIL LENGTH IN THAMNOPHIS SAURITUS.

somewhat greater in eastern localities. This is shown better in the number of subcaudal plates (fig. 50). Thus, in Ohio, Michigan, and Indiana the extreme number of subcaudal plates is 87 and 121, the averages between 100 and 117, while along the coastal plain the extremes are 103 and 137, the averages between 115 and 120. (No

differences in color have been observed which are evidently geographic.)

If the data plotted can be depended upon to reveal the actual state of variation, the form may thus be divided into two sections upon the basis of the scutellation and tail length, i. e., a trans-Allegheny section characterized by a larger number of ventral scutes, a shorter tail and fewer subcaudal scutes, and a coastal plain section characterized by a fewer number of ventral plates, a longer tail and more subcaudal scutes.

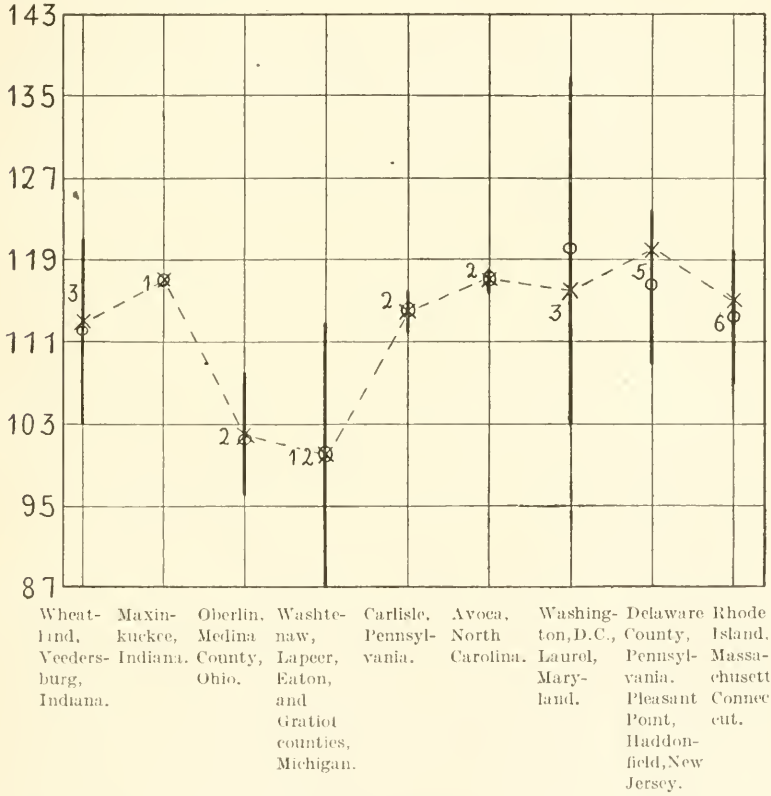

FIG. 59.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUBCAUDAL SCUTES IN THAMNOPHIS SAURITUS.

Affinities.—The position of the lateral stripe (on the third and fourth rows) and the long tail justifies us in placing *sauritus* in the same group with *sackeni* and *proximus*. As has been shown, it meets the range of *sackeni* in the latitude of northern Florida and that of *proximus* along the eastern boundary of Illinois and in western Kentucky, Tennessee, and Mississippi. Specimens from the intermediate region along the common boundaries of the three forms remain to be examined, but I believe that there can be no doubt that *sauritus* intergrades perfectly with both *sackeni* and *proximus*.

Sauritus differs from *sackeni* principally in its generally fewer number of labials, subcaudals, and ventral scutes and the shorter tail, and from *proximus* in the fewer labials and ventral scutes and greater number of subcaudals and slightly longer tail. A comparison of the tables, however, will show that these differences are not sharp. Thus, while the usual number of labials in *sackeni* are 8/10, the formula 7/10 is not rare, while in *sauritus* the general formula 7/10 is not infrequently replaced by 8/10. This suggests that the two forms may intergrade in this trait, although the data are not sufficient to establish this geographically.

It has previously been noted that *proximus* specimens from the eastern part of the range show an apparent tendency toward a reduction in the number of supralabials from 8 to 7, the average number for Illinois specimens being almost identical with the average for Indiana specimens of *sauritus*. Very similar conditions exist in the case of the other characters. In coastal plain specimens of *sauritus* the extremes of variation in the number of ventral scutes are quite close to those of *sackeni*, although the averages are somewhat lower. In southern Michigan, Ohio, and Indiana, however, the number of scutes in this series is apparently higher than in either the coastal plain specimens of *sauritus* or *sackeni*, which brings the form in this region so close to *proximus* specimens from Illinois, eastern Iowa, and St. Louis that the character is useless as a distinguishing one. Again, the greater number of subcaudal scutes and the tail length in coastal plain specimens of *sauritus* approximate the conditions in *sackeni*, while the shorter tail and fewer subcaudals in western specimens of *sauritus* are almost identical with eastern specimens of *proximus*.

It seems very evident from this digest of the variations in the three forms (1) that the form *sauritus* intergrades both with *sackeni* and *proximus;* (2) that the longer tail, more numerous subcaudals, and fewer ventrals relate the specimens of *sauritus* from the eastern coastal plain more closely to *sackeni*, while the shorter tail, fewer subcaudals, and greater number of ventral scutes relate the interior specimens directly to *proximus*.

I suggest, then, that the form now known as *sauritus* has had a double origin, i. e., the coastal plain section from *sackeni* and the trans-Allegheny section directly from *proximus*. This is what we might expect, for the fact that the ribbon snakes are so eminently adapted to the coastal plain conditions would favor the rapid invasion of the eastern coastal plain from Florida, while the Appalachian system would prove more of a barrier to such an aquatic form than to a more terrestrial one, and permit the section from beyond the Mississippi to push into the region west of the Appalachians. However this may be,

it should be noted that *sauritus* as a form has, exclusive of the dorsal scale rows, a smaller scutellation generally than either *sackeni* or *proximus*.

CONCLUSION.

In the foregoing pages we have endeavored to give the results of a study of the characters, habitat relations, variations, and affinities of the three forms, *proximus*, *sackeni*, and *sauritus*, which are apparently united into a single group by the position of the lateral stripe upon the third and fourth rows and the long tail. The evidence seems to indicate that the three forms intergrade perfectly with each other, but even though the evidence may be considered too slight to prove this, I believe it to be indisputable that the closest relationships of these forms are along the common boundaries (fig. 51).

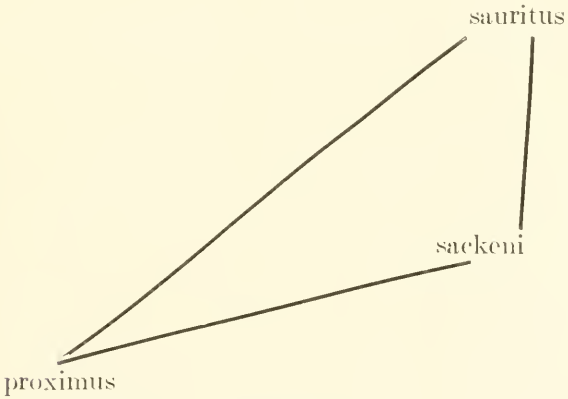

FIG. 51.—PHYLOGENETIC DEVELOPMENT OF THE SAURITUS GROUP.

Of the three forms, *proximus*, in northern Mexico and Texas, possesses the maximum scutellation (exclusive of the subcaudal plates) and *sauritus* the minimum, *sackeni* possessing an intermediate number. The decrease takes place gradually from *proximus* to *sackeni* to the coastal plain section of *sauritus* and from *proximus* directly to the trans-Allegheny section of *sauritus*. The tail length and number of subcaudal plates increase somewhat from *proximus* to *sauritus* and markedly from *proximus* to *sackeni*, apparently decreasing again in the coastal plain specimens of *sauritus*, thus approaching the shorter-tailed conditions in the trans-Allegheny section of the latter. It must also be stated that according to my observations *proximus* specimens attain to the largest size.

The center of origin of this group will be discussed later (see p. 187), but it may be stated here that I believe the center of dispersal to be in northern Mexico. If the group did originate in this region the explanation for its present distribution would seem clear. Being rather aquatic in its habits, we would expect the original stock to

adhere quite closely to the coastal plain in Mexico, but in the United States it has apparently been able to push out along the rivers, the westward trend of the streams permitting it to cross the plains and prairies, the Mississippi to extend its range well to the northward. East of the Mississippi River the group has been able to extend over all of eastern United States, the coastal plain leading one section from the coastal plain of Texas and Louisiana into Florida and from here up the Atlantic coast, the other section pushing into the trans-Allegheny States from the Mississippi Valley. It should be noted again in this connection that a reduction in scutellation and size in the group takes place away from northern Mexico, both to the south and east (the extremities of the range of the group), and that the area between the forms, in which a difference in scale formulas is accomplished, is in every case narrow.

THE ELEGANS GROUP.—(ANGUSTIROSTRIS, MELANOGASTER, SCALARIS, PHENAX, HAMMONDI, ELEGANS, ORDINOIDES.)

ANGUSTIROSTRIS.[a]

Description.—If in assembling these forms of garter-snakes I have distinguished a natural group I should be able to support my position by pointing out the lines of relationship between the component forms. As in the *Radix* group, I begin with the forms on the Mexican table-land, one of which (*angustirostris*) also possesses the maximum scutellation for the group. Apparently not over a dozen specimens of this form have been recorded, although it is probably not rare in the region where it is found.

In appearance it is one of the most peculiar forms in the genus. The stripes are usually entirely wanting, but the laterals are occasionally faintly in evidence on the second or second and third rows, and the dorsal for a short distance anteriorly on the median row. The scutellation in the specimens examined is as follows: Dorsal scale formula, 21–19–17, with occasional variations to 21–23–21–19–17 and 19–21–19–17; supralabials, 8 to 9; infralabials, 10–11 (9 in one instance); preoculars, usually 3; postoculars, 3 to 4; subcaudals, 65 to 83; ventrals, 153–163; tail length, .235 to .256. The eye is generally cut off from all but one labial by the anterior prolongation of the lower postocular, but this is not always the case.

The color above is usually dark olive brown, with six rows of dark brown spots on the scales, distinct in the young, but indistinct or obsolete in the adults. The head is also unicolored above in the adults, while in the young it is finely speckled with lighter. Each upper and lower labial is margined with a triangular patch of brown

[a] *Thamnophis angustirostris* (Kennicott), Proc. Acad. Nat. Sci. Phila., 1860, p. 332. This form includes *Atomarchus multimaculatus* Cope and *Chilopoma rufopunctatum* Cope.

bordered with darker. Belly greenish or bluish ash, marked with numerous small black spots, and a bar at the base of each ventral, which is usually prolonged outward to form a more or less irregular median ventral band. Throat yellow.

Habits and habitat relations.—Little data is available on the habitat relations of this snake, but it is undoubtedly particularly aquatic in its habits. Thus, Cope (1883b) states of the San Francisco River specimen obtained by him:

> The only specimen of this species which I have seen living was taken in a seine net with which I was fishing near the bank of the San Francisco River. It dove into the net, seeking the bottom of the water as a place of concealment, as is the habit of *E. melanogaster* and contrary to that of *E. saurita* and *E. macrostemma*, which swim preferably on the surface, seeking concealment under banks.

Range.—As at present known, this form is confined to the northern part of the Mexican plateau (above northern Durango) and the proplateau region in southwestern New Mexico and southeastern Arizona (fig. 52). The conditions of this habitat have already been described (p. 46). Specimens have been examined from Chihuahua and San Andreas, Chihuahua; Parras, Coahuila, and Coyotes, Durango, but it occurs also in southern Arizona, as Cope (1883b, 1300–1301) records a specimen from the San Francisco River in southern New Mexico, and the type of *rufopunctatum* came from "southern Arizona."

Variation.—Very few facts are available for the study of variation in this form. The dorsal scale rows are very constantly 21–19–17. A single specimen from San Andreas, Chihuahua, has 21–23–21–19–17, and another from Chihuahua, Chihuahua, has 19–21–19–17. No geographic variation is discernible in this character in the material at hand, the more northern and southern specimens all having generally 21–19–17 rows. The same thing is true of the labial scutes, the formula being 8/10 or 8/11, or 9/10 or 9/11, but with no certain differences in those from different localities, although only those from Chihuahua have 9 in the superior series.

In regard to the ocular scales the conditions are somewhat different. In all of the specimens examined from the vicinity of Chihuahua, Chihuahua, there are three preoculars and three or four postoculars, and the eye is excluded from the posterior subocular labial by the lower postocular, but in those from northern Durango and southern Coahuila the formula is 2–3 or 1–3 and the eye is fairly in contact with two labials. Similarly the type of *rufopunctatum* from "southern Arizona" is said to have had one preocular on one side and two on the other, as well as three and four postoculars, with the eye in contact with two labials. But little idea can be obtained as to the range or mean in the variations of the ventral and subcaudal scutes. In the material examined the males have in general 162–166 ventrals and 73–83 subcaudals, the females 153–159 ventrals and 64–69 sub-

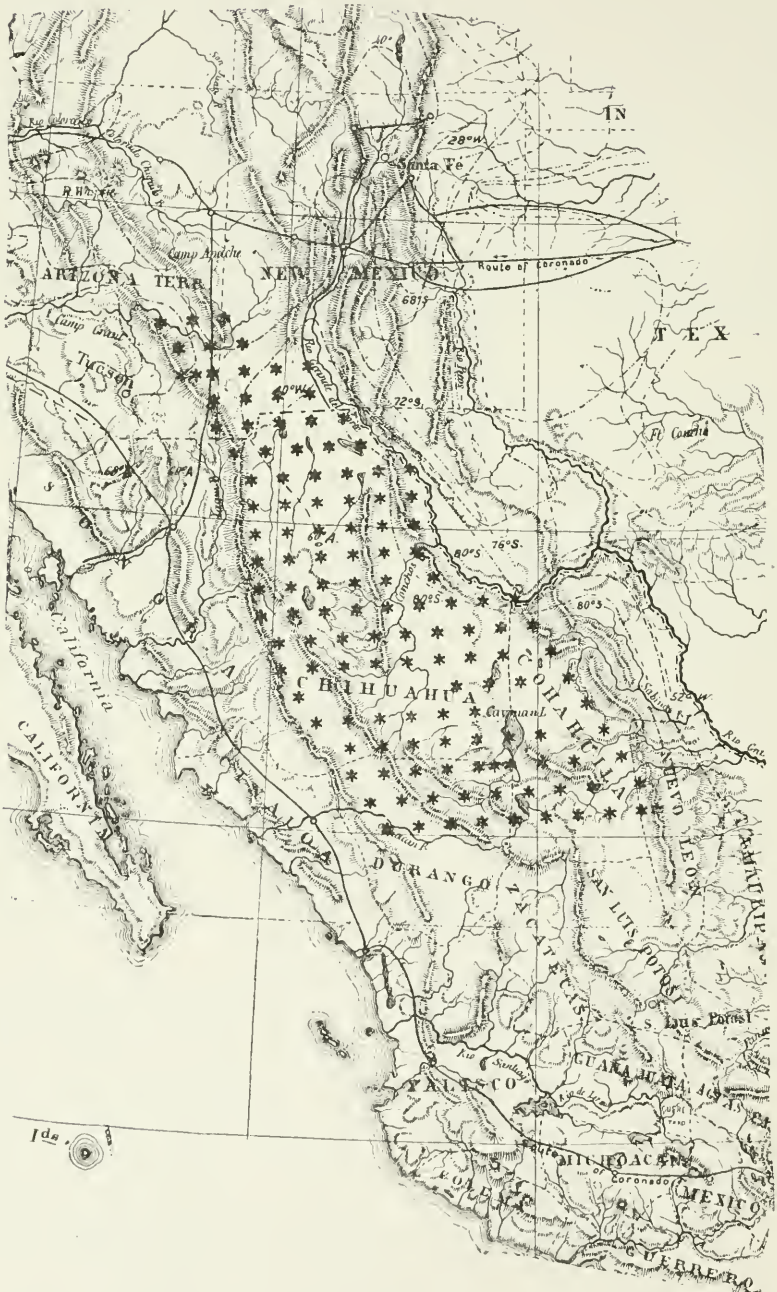

FIG. 52.—DISTRIBUTION OF THAMNOPHIS ANGUSTIROSTRIS AS INDICATED BY THE LOCALITY RECORDS.

caudals. The tail length varies from .22–.256, the average of males and females combined being about .225.

It is needless to point out that these figures can not be relied upon to furnish more than a general idea of the scutellation and proportions in this form. Still, the more constant characters seem to indicate (1) that in the vicinity of the city of Chihuahua the number of dorsal scale rows, oculars, and possibly the labials reach the maximum for the form, and also for the group and genus; (2) that toward the northern and southern limits of the range the number of oculars, especially the preoculars, tends to decrease; (3) that the orbit, which in every specimen from the vicinity of Chihuahua, Chihuahua, is separated from all but one labial by the inferior postoculars, becomes fairly in contact with two in the northern[a] and southern parts of the range.

Affinities.—In the most southern localities from which it is known *angustirostris* comes in contact with *melanogaster*. These forms always resemble each other closely in that both are characterized by a slender head, small eye, mostly 8 supralabials and 10 infralabials, nearly the same number of ventral scutes, more than one preocular, the absence of the dorsal stripe, and the presence of a dark median ventral band. The differences between them are that in specimens of *angustirostris* there are generally well-defined blotches on the labials, the lateral spots are usually in evidence, the lateral stripes generally obsolete, the eye usually in contact with but one labial, and not less than 21–19–17 scale rows. While in *melanogaster* there are no large blotches on the labials or evidence of lateral spots, the lateral stripe is often present, the eye is in contact with two labials, and the dorsal scale formula rarely exceeds 19–17.

It may be seen from this that the differences between the two forms are slight except in two particulars, the segregation of the eye from the second subocular labial and in the dorsal scale formula. In regard to the former trait we have already shown that in the region which these forms hold in common *angustirostris* becomes exactly like *melanogaster* in the fact that the eye is in contact with two labials. It will also be shown in the consideration of *melanogaster* that the number of rows of dorsal scales tends to become as in *angustirostris* (21–19–17 or 19–21–19–17). The evidence, therefore, favors strongly the view that the two forms intergrade in northern Durango and southern Coahuila, so that it must be adopted for the present, although the relationships of the two forms in the intermediate region should

[a] In the type of *multimaculata* (from the San Francisco River) the eye is in contact with but one labial, but in *rufopunctatum*, as already mentioned, it is bounded by two.

be carefully investigated before any definite conclusion can be reached.[a]

Elsewhere in its range *angustirostris* is not known to meet any similar form, but to the northward the known limit of its range approaches that of one which is strikingly like it in many respects. I speak of *T. hammondi* (Kennicott). The points of similarity between these forms will be discussed when *hammondi* is considered in detail.

MELANOGASTER.[b]

Description.—I have already stated that this species resembles *angustirostris* so closely as to suggest strongly a near relationship. The head is slender and the eye small. Lateral stripes usually present, and confined to the second row of scales. The dorsal stripe is usually wanting, but may be present on the median row. Dorsal scale formula, 19–17; the labials, 8/10 (very rarely 7/10, 8/9, or 8/11); oculars, usually 2–2 or 2–3, occasionally 2–4 or 3–3; ventral plates, 139–158; subcaudals, 49–76; proportionate tail length, .19–.26. The color above is uniformly very dark brown without distinct spots. Both the dorsal and lateral stripes are indistinct when present. Belly greenish slate or yellowish ash, with a black bar on the base of each ventral, which is prolonged in the middle to form a median ventral band. Throat and supralabials dark yellow.

Habits and habitat relations.—Like its northern relative, *angustirostris*, *melanogaster* is apparently quite aquatic in habits. The following account of its habits at the City of Mexico, recorded by Cope, has already been quoted in the discussion of the habits of *megalops*.

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[a] Kennicott's type of *angustirostris* (Parras, Coahuila) is not exactly typical of the northern form, as the eye is fairly in contact with two labials; but while it is thus somewhat intermediate between the northern and southern forms, it is much closer to the former, as shown by the coloration and the possession of 21–19–17 scale rows, thus making it entirely fair to give this name to the form.

[b] *Thamnophis angustirostris melanogaster* (Peters), Monats. König. Preuss. Akad. Wissen. Berlin, 1864 (1865), pp. 389-390. Includes *Tropidonotus baronis-mülleri* Troschel, *Tropidonotus mesomelanus* Jan, and *Regina mesomelaena* Cope. The fact that Peters states that "Diese Art ist bereits von Wiegmann (*Preisverzeichniss der Säugethiere, Vogel, Amphibien, Fische, und Krebse, welche von Hrn. Deppe und Schiede in Mexico gesammelt worden, Berlin, 1. Sept., 1830;* wieder abgedruckt in Cabanis Journal fur Ornithologie, 1863, p. 54) benannt und unter dem obigen Namen versandt und verkauft worden" has led Cope to credit this name to Wiegmann. Inasmuch, however, as Peters first described the species, he should be held responsible for the name, for Article 21 of the International Code distinctly says that "The author of a scientific name is that person who first publishes the name in connection with an indication, a definition, or a description, unless it is clear from the contents of the publication that some other person is responsible for said name and its indication, definition, or description," and Wiegmann, as is well known, gave no description of this species.

The *E. macrostemma* is the more active, sooner seeking the water, where it swims keeping close to the shore, and remaining more or less in sight until it conceals itself in a hole. The *E. melanogaster*, on the other hand, lies quietly so as to be more easily taken in the hand; but, if it once takes to the water, it seeks the depths and is no more seen. It is much less disposed to bite than the *E. macrostemma;* the latter being, like its ally, the *E. sirtalis*, a very pugnacious snake.

A number of specimens have been taken about Lakes Xochimilco and Chalco, Mexico.

Range.—In contrast to *angustirostris*, which occurs on the northern part of the Mexican plateau, *melanogaster* has thus far been recorded only from that part of the plateau which lies south of the 26th parallel. From this latitude it extends southward to Puebla, but has not been recorded from that State. Over the northern part of this region the environmental conditions are the same as in the northern part of the plateau, but to the southward the precipitation increases with the result that permanent rivers and lakes are formed.

Specimens have been examined from the following localities: Coyotes and Durango, Durango; Ocatlan, Jalisco; Lakes Xochimilco and Chalco, and Mexico City, Mexico; besides a number of others with no other locality label than "Mexico." Günther (1894, 134) records the following general localities: Guanajuato, Veracruz, Tehauntepec. Owing to its relationship to *angustirostris*, we do not believe that it occurs north of Coyotes, Durango, but the locality records probably do not represent the southern limit of its range (fig. 53).

Variation.—As in the case of *angustirostris*, far too few specimens of this snake are available to reveal whether or not geographic variation in scutellation exists. Certain general facts should be pointed out, however. The dorsal scale formula is 19–17 in every specimen examined, the ventral plates vary in number from 139–158 (average 145–150), the subcaudals from 49–67 (average about 58). These numbers indicate plainly that *melanogaster* has a distinctly reduced scutellation from the maximum for the genus, a fact which is not disproved by the labial formula. Thus, the supralabials are nearly always 8, the only differences consisting of a loss of a single plate, while the normal number of infralabials (10) becomes occasionally 9, and in but one instance 11. The tail length, as previously stated, varies from .19 (female) to .26 (male), the average length for every locality with two or more specimens being .22.

Affinities.—I have already pointed out in the discussion of the affinities of *angustirostris* that these two forms are evidently related in that the strongest distinguishing characters possessed by *angustirostris* (the segregation of the eye from all but one labial and the presence of more than two preoculars) apparently disappear in that part of the range which it shares with *melanogaster*. It is natural

to inquire now what particular evidence, if any, *melanogaster* shows of such consanguinity. Since we are inhibited by a lack of specimens from determining geographic variation, we can expect but little evidence from one form when the two are so very similar.

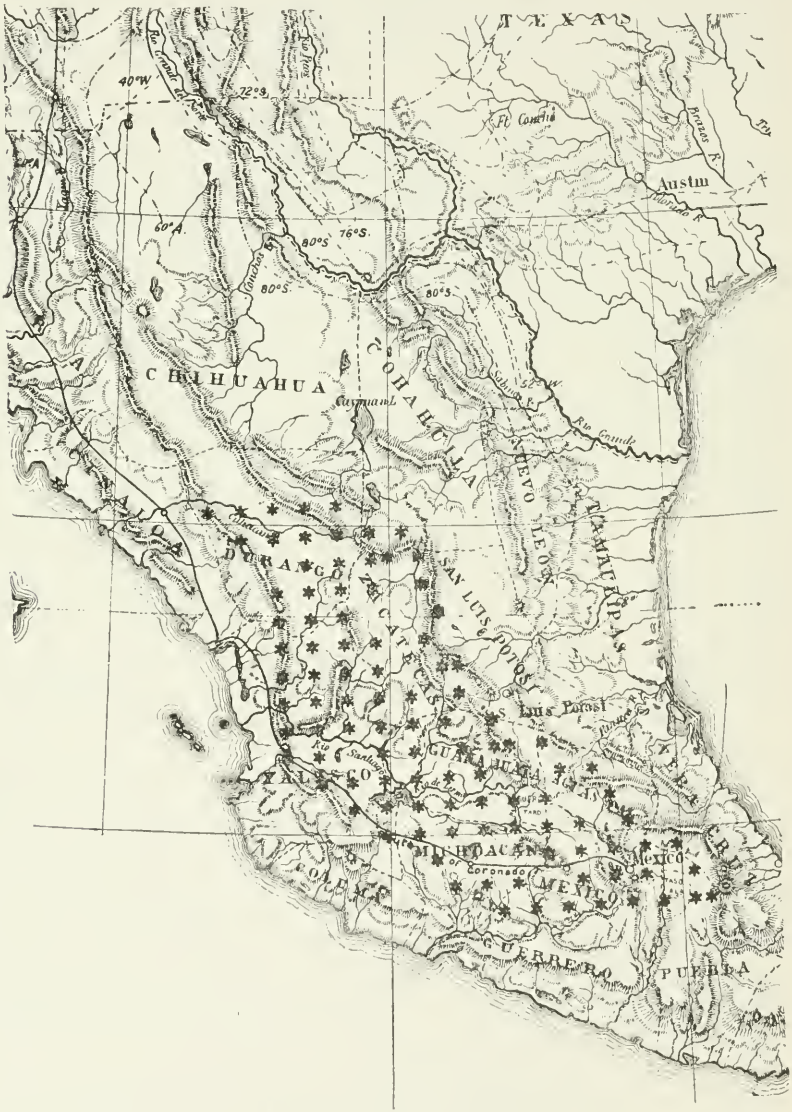


FIG. 53.—DISTRIBUTION OF THAMNOPHIS ANGUSTIROSTRIS MELANOGASTER, AS INDICATED BY THE LOCALITY RECORDS.

Specimens of the two forms are so nearly alike both in scutellation and color, that it is impossible to give any character that will always serve to distinguish them; but whether or not we grant that intergradation occurs at the present time, I hold it to be quite evident

that they are directly related. In this connection it should be noted that apparently in every series of scales *melanogaster* is more reduced than *angustirostris*. In the south *melanogaster* comes in contact with two very imperfectly known forms with which I believe it also to be related; these are *scalaris* and *phenax*, which will next be discussed.

SCALARIS.[a]

Description.—It is nearly always difficult to properly determine the characters and affinities of forms which are known from but few localities, owing to the fact that geographic differences are seldom revealed. This is particularly true of the garter-snakes of southern Mexico and Central America, a region from which a number of species have been described, none of which are represented in American museums by more than a few specimens. Of these forms *scalaris* is perhaps the best known, but, although access has been had to the material in the U. S. National Museum, Academy of Natural Sciences of Philadelphia, and the Field Museum of Natural History, it has been possible to find a total of but nineteen specimens, representing five localities.

As known at present, the form may be described as follows: Lateral stripe on the second and usually the adjacent edge or half of the third rows. Eye small. Dorsal stripe principally confined to the median row. Dorsal scale formula, 19–17, 19–17–15, 17–19–17, 17–19–17–15, or 17–15; supralabials, 7, very rarely 8; infralabials, usually 9, occasionally 8 or 10; oculars, 1–3 or 1–2; ventrals, 134 (female) to 151 (male); Subcaudals, 52 (female) to 76 (male).

Ground color above brownish ash, olive brown, or dark chocolate brown; the first row somewhat lighter. Stripes light ash to dull orange yellow. In some specimens there are no lateral spots to be observed on the scales, and in others there is a row of dark transverse bars between the third and seventh rows, inclusive, which alternate with a series of small spots on the eighth and ninth rows. In the majority of specimens, however, there is on either side a single series of large (one and one-half scales wide and one apart) rectangular, transverse, dark brown spots with dark edges, which extend from about the middle of the third to the median row of scales. These spots are well defined from the nape (where they are represented by a pair of large nuchal blotches) to the anus, are as distinct in the young of the single brood examined as in the adults, and the spots of each side are only separated by the dorsal stripe on the median row. Head above brown, generally marked with dusky yellow. Postoculars and supralabials dusky yellow. The plates in the latter series may not be margined with darker.

[a] *Thamnophis scalaris* Cope, Proc. Acad. Nat. Sci. Phila., 1886, p. 306. Includes *T. scaliger* Jan.

Habits and habitat relations.—Nothing is known of the habits of this form, but it is significant that several specimens in the U. S. National Museum, collected by F. Sumichrast, are labeled "Alpine region," by which is probably meant the pine zone surrounding the zone of grasses and herbaceous forms which margins the snow fields and glaciers of the summit. Dr. W. L. Tower informs me that the pine zone attains a maximum elevation of 13,000 or 13,500 feet. That *scalaris* occurs in this habitat is shown quite clearly by the fact that a series of specimens in the Field Museum of Natural History were taken at an elevation of 13,000 feet. These are the only available notes on the habitat of the form.

Range.—All that is known of the range of *scalaris* is indicated by the following records: Guanajuata; Jalapa and Mount Orizaba, Vera-

FIG. 54.—DISTRIBUTION OF THAMNOPHIS SCALARIS, AS INDICATED BY THE LOCALITY RECORDS.

cruz; Valley of Mexico and Toluca, Mexico; Tecpam, Guatemala; Talpa and Autlan, Jalisco; Oaxaco. We have examined specimens from all but the last three localities (Boulenger, 1893, 204). (Fig. 54.) Whether or not it is of general distribution in the region indicated by these records can not be conjectured, as practically nothing is known of its habitat relations.

Variation.—It is highly inexpedient to attempt to draw conclusions on the nature of the variations in such a small series as is here available more especially since fifteen out of the nineteen specimens hail from one locality. In the accompanying table, however, we give the scutellation and measurements of all of the specimens examined, and notwithstanding the scarcity of material certain facts stand out quite prominently. Thus, the *sixteen specimens from Orizaba and Jalapa,*

Veracruz, all have 17–19–17 scale rows or less, while none of the three specimens from the States of Mexico and Guanajuato have other than 19–17–15, and one of the Guatemala specimens has 19–21–19–17. Such a reduction in the number of scale rows would represent a dwarfing within the form, but, regardless as to whether or not this apparent tendency is borne out by future investigations, it is quite evident from the predominance of the smaller dorsal scale formulas together with the evidently small number of labials that the form is, as a whole, a dwarfed one, so much so indeed that the number of scales in the dorsal, supralabial, infralabial, and ventral series attains the minimum for the genus, the form being more reduced than *butleri* in this regard. It should also be noted that the size of all of the specimens obtained is small.

Measurements and scutellation of Thamnophis scalaris Cope.[a]

Museum.	Number.	Locality.	Dorsals.	Supralabials.	Infralabials.	Oculars.	Subcaudals.	Ventrals.	Total length.	Tail length.	Percentage of tail to total length.
									mm	*mm*	
Field Museum	1517	Orizaba, Veracruz	17-19-17-15	7	9/10	1-3	61	141	.....	.....	.....
Do	1517	Mount Orizaba, Veracruz.	17-15	7	9	1-2	74	138	172	47	0.27
Do	1517	.....do	17-15	7	8	1-3	68	137	.....	.....	.....
Do	1517	.....do	17-15	7	9/10	1-2	65	136	173	44	.25
Do	1517	.....do	17-19-17-15	7	9	.....	66	140	175	43	.24
Do	1517	.....do	17-19-17-15	7	8	1-2/1-3	60	138	178	42	.23
Do	1517	.....do	17-15	7	8	1-2	75	137	170	47	.27
Do	1517	.....do	17-15	7	8/9	1-2	75	138	180	50	.20
Do	1523	.....do	17-19-17	7	9	1-3	61	144	.....	.....	.....
U. S. National Museum.	12115	Orizaba, Veracruz	17-19-17-15	7	9	1-3	59	135	347	82	.23
Do	30497	.....do	17-19-17-15	7	10	1-3	75	145	316	81	.25
Do	7076	"Alpine region," Orizaba, Veracruz.	17-19-17-15	8/7	10	1-3	58	145	406	90	.22
Do	7076	.....do	17-19-17-15	7	8/9	1-3	76	134	185	50	.27
Do	7076	.....do	17-19-17-15	7	9	1-3	72	137	207	53	.25
Do	7076	.....do	17-15	7	9	1-2/1-3	73	142	335	100	.29
Do	32281	Valley of Mexico and Toluca.	19-17	7	9	1-3	52	143	385	79	.20
Do	12675	Guanajuato	19-17-15	7	9	1-2	56	144	387	80	.20
Do	12730	Mexico, Mexico	19-17	7	9	1-2/1-3	52	151	410	78	.19
Academy Natural Science, Philadelphia.	11694	Jalapa, Veracruz	17-19-17-15	7	9	1-3	73	138	340	95	.28

[a] Since this table was compiled I have examined four specimens of *scalaris* from Teepam, Guatemala, in the Field Museum. Three have 19-17 and one 19-21-19-17 scale rows.

Affinities.—Little reliance can be placed on efforts to determine in more than a general way the affinities of this form, but something can be done in this direction. In the first place, if we can pin our faith to the constancy of the trait, the position of the lateral stripe on the second and third rows at once excludes *scalaris* from the *Radix* and *Sauritus* groups. On the basis of our classification, then, it is to be referred either to the *Sirtalis* or *Elegans* groups. The latter has otherwise, so far as we know, no representatives in this region, but the ground for referring it to this group is mostly the negative one that the former group (*Sirtalis*) covers the same territory as *scalaris*, which argues against a relationship in this direction.

If *scalaris* is a derivative of the *Elegans* group it is quite important that its relationship with *melanogaster* (the nearest form, geographically, of the same group) be determined by careful collecting and observation. From the present data the ranges of the two forms seem to overlap in southern Mexico, but the habitats of the two may be quite distinct, a conclusion that is strengthened by the fact that on Mount Orizaba *scalaris* is found, to some extent at least, at a considerable altitude. On the other hand, it is not impossible, and I rather incline toward the hypothesis, that *scalaris* is more closely related to *elegans* than to any other form, and represents an offshoot of the latter which has pushed southward from the range of *elegans*, in the mountains of eastern Mexico. In defense of this view, it is interesting to note that *elegans* prefers comparatively high altitudes in the Rocky Mountains. At any rate, it is, as known at present, a well-defined form, which is liable to confusion only with *phenax*. Its relations to *phenax* will be discussed in considering the affinities of the latter.

PHENAX.[a]

Description.—The status of this form is much the same as that of *scalaris*. At the present time I know of but two specimens in American museums. Cope writes that specimens have been sent to both the Academy of Natural Sciences of Philadelphia and the U. S. National Museum, and records six specimens from the latter institution, but the only ones that I have been able to find in either museum is the type and a small individual, both in the National Museum. The proportions and scutellation of these specimens is given in the following table:

[a] *Thamnophis phenax* (Cope), Proc. Acad. Nat. Sci. Phila., 1868, p. 134.

Measurements and scutellation of phenax.

No., U.S.N.M.	Locality.	Dorsals.	Supralabials.	Infralabials.	Oculars.	Ventrals.	Subcaudals.	Total length.	Tail length.	Proportionate tail length.	Remarks.
								mm	*mm*		
30499	Orizaba, Cordova, Veracruz.	19-17	8	9	1-3	161	65	605	130	0.22	Type.
30498	.....do.....	19-17	7	9 10	1-3	158	73	275	67	.24	Immature.

There are no lateral stripes. In the type specimen No. 30499 (which has been in alcohol for many years) the ground color above is brownish olive (said to have been reddish olive in life) with a series of slightly darker cross-bands which extend entirely across the back to the second row of scales. These cross-bands (which are said to have been bright brownish red when the specimen was fresh) are about four scales wide and one and one-half scales apart, and are margined on the longer sides by black borders one-half scale wide, which, owing to the inconspicuousness of the spots themselves, give the snake the appearance of being cross-banded by paired narrow black bars. The nuchal spots are quite similar to the dorsal band in being but little darker than the ground color and heavily margined with black, but they differ from those of the dorsal series in being interrupted on the median line, the posterior black border on either side bending forward to the parietal plates. There is a trace of a dorsal stripe on the nape, between the nuchal blotches. No definite series of spots on the first row of scales. Head brown, marked with black. Supralabials brownish yellow (said to have been light olive in the fresh specimen), and, with the exception of the sixth, partly margined with black.

In the second specimen, No. 30498, the pattern differs from that of the type in that *the cross-bars are often interrupted along the median line,* in the presence of the spots on the first row of scales, that anteriorly form a definite row which alternates with the second, and the fact that the nuchal spots are fused across the nape, being strongly notched behind and separated in front by a light line that is continued along the parietal suture to the frontal.

Range.—Both of the specimens described above are labeled "Orizaba, Cordova." The type was listed by Cope as from "Cordova, Vera Cruz," and the locality of the six specimens recorded in 1898 was given as Orizaba, Vera Cruz. The label "Orizaba, Cordova" seems to mean, not that the specimens came from the towns Orizaba and Cordova, but from Mount Orizaba, in the canton Cordova. The range is thus apparently within the range of *scalaris.*

Variation.—If the specimens listed in the table are typical of this form, it is interesting to note that the scutellation is somewhat reduced, as shown by the dorsal scale formula of 19–17 and the tendency toward the labial formula 7/9. The other scale formulas can not of course be determined on the basis of two specimens, but it is evident that the tail is not long, as in the *Sauritus* group.

Affinities.—As illustrated by the described specimens, the coloration of *phenax* is strikingly characteristic, so that a much larger series of specimens must be examined before a serious attempt can be made to discover its affinities. Unfortunately we do not have the lateral stripe to aid us, as this is obsolete in the specimens examined, so that we must depend on the other characters. That it is not to be referred to the *Radix* or *Sauritus* groups seems to be sufficiently indicated by the fact that the forms of these groups, which occur in Mexico, show no tendency to acquire the *phenax* type of coloration, although two forms of these groups (*proximus* and *megalops*) come very close to or possibly overlap the range of *phenax*. Furthermore, on the same grounds we believe it to be very improbable that the form in question is to be referred to the *Sirtalis* group.[a]

The most probable near relative of *phenax* is, in my estimation, *scalaris*. Thus, as far as is revealed by the material examined, the scutellation and tail length is exactly similar to that of some specimens of *scalaris*, while the coloration of the former resembles that of the latter, as it does no other in the genus. Thus, in *scalaris*, as already pointed out, the large transverse blotches encroach upon the stripes which are narrow, and it only requires that these blotches of the opposite sides be continued across the back and the stripes entirely obliterated to produce a type exactly like *phenax*. It is interesting to note that in one specimen of *phenax* examined the crossbars are interrupted to some extent along the median dorsal line, producing two series of lateral blotches, as in *scalaris*, and that the general type of coloration exhibited by these two forms occurs nowhere else in the genus. I believe, therefore, that the two are very closely related, and since they are apparently found in the same localities it is most probable that the so-called *phenax* specimens simply represent individuals in which the process leading to the type of coloration exhibited by *scalaris* has been continued farther to the total obliteration of the stripes and the fusion of the lateral crossbars across the median region of the back. The distinctness of the form should be adhered to, however, until settled by more extensive investigation.

[a] Bocourt (Miss. Sci. Mex., Rept., 1893, p. 778) makes *phenax* a subspecies of *cyrtopsis* (*eques*), thus linking it with the *Sirtalis* group. I can find no justification for this except the similarity in scutellation, an unreliable factor upon which to base such conclusions, unless it be controlled by others. It will be shown later that *eques* is represented in this region by one dwarfed form, and that the latter is quite distinct from *phenax*.

HAMMONDI.[a]

Description.—This form, which was long considered a subspecies of *elegans*, has in late years been given the rank of a species. Any general description will not describe it accurately owing to the variableness of the most distinctive characters. A grayish or brownish yellow stripe on the second or second and third rows. Dorsal stripe usually wanting, occasionally represented on the nape, rarely present for the entire length and then but faintly. Dorsal scale formula, 21–19–17 (occasionally 19–21–19–17). Supralabials, 8 (rarely 9). Infralabials, 10 (occasionally 9 or 11). Oculars, 2–3, 2–4, 1–2, or 1–3. Subcaudals, 65–96. Ventrals, 155–178. Proportionate tail length, .21–.27. Color above the lateral stripes dark grayish or olive brown, marked with four rows of small alternating black spots. First row usually a little lighter than above and with or without a small black spot on the base of each scute. Small nuchal blotches. Belly greenish or yellowish ash without a median ventral shading formed by the median prolongation of the black bars at the base of the ventral scutes.

Habits and habitat relations (fig. 55).—The only observations known to me on the habits of this snake are those recorded by Van Denburgh and Grinnell:

> Like other members of its genus, this snake swims well and is usually found in or near water. Its food consists mainly of aquatic animals, such as fish, frogs, and tadpoles. One specimen was caught with a good-sized trout in its teeth. (Van Denburgh 1897, 214.)
>
> This is the water snake of the mountain regions, and is abundant in summer along the San Gabriel, Arroyo Seco, and Tujunga canyons. It occurs also tho more sparingly in the smaller canyons and out along the water courses a few miles into the valley country.
>
> Many years ago before the pumps had drained the water from the Arroyo bed west of Pasadena there was a good-sized stream there all summer. Along this stream the California garter-snake was very common. There were sometimes four in sight at once along the sandy banks. When alarmed they would take to the water and disappear into the deeper places for a short time or swim gracefully across the brook and crawl out on the opposite bank.
>
> This snake feeds on tadpoles, small frogs, and fish. We have seen a garter-snake so gorged with tadpoles that when alarmed it had to give up some of its cargo, the released tadpoles wriggling out of the snake's mouth apparently none the worse for wear. (Grinnell, 1907, 49–50.)

Range.—This species is only known from southern California and northern Lower California. The specimens examined represent the following localities: La Guilla, San Pedro Martir Mountains, and San Antonio, Lower California; Twin Falls, Soda Springs, Los Angeles San Bernardino County, San Diego County, Fort Tejon, Fresno, Alvord, Cartago, Bishop, South Fork Kern River (25 miles above Kernville), Kern River Lakes, Kern Lake, California; "Mohave Desert, Arizona."

[a] *Thamnophis hammondi* (Kennicott), Proc. Acad. Nat. Sci. Phila., 1860, p. 332. Includes *E. couchi* and *E. elegans couchi* of various authors, but not of Kennicott.

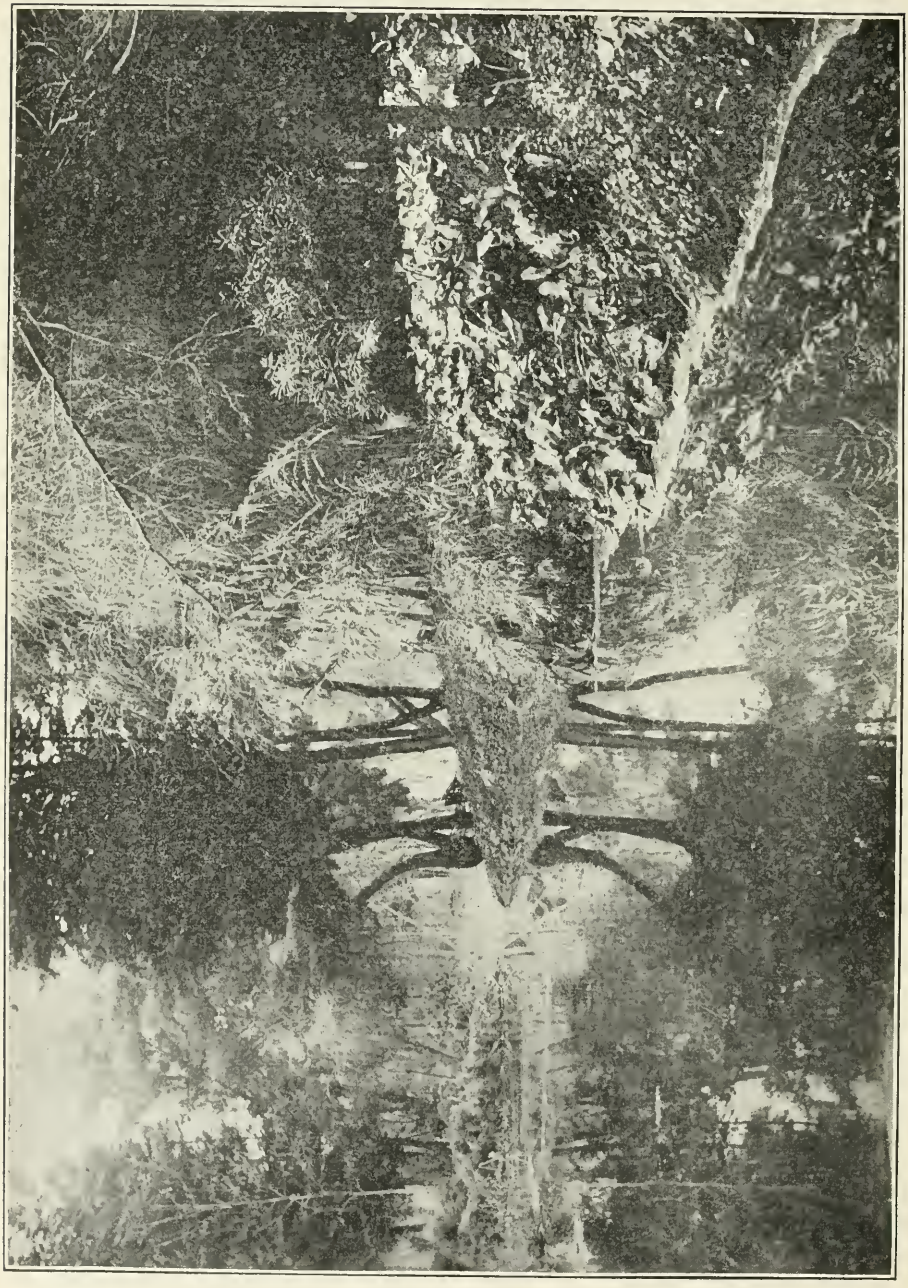


FIG. 55.—HABITAT OF THAMNOPHIS HAMMONDI. STREAM AT BALDWIN'S RANCH, ABOUT 20 MILES EAST OF LOS ANGELES, CALIFORNIA.

The most northern localities from which we have examind specimens are Owens Lake, Kernville, and Fresno, California, the latter locality indicating that it enters the interior valley of California. To what extent it occurs in this valley can not be determined until its relation to *elegans* is known. The southernmost locality in which it has been found is La Guilla, Lower California. The form is thus known

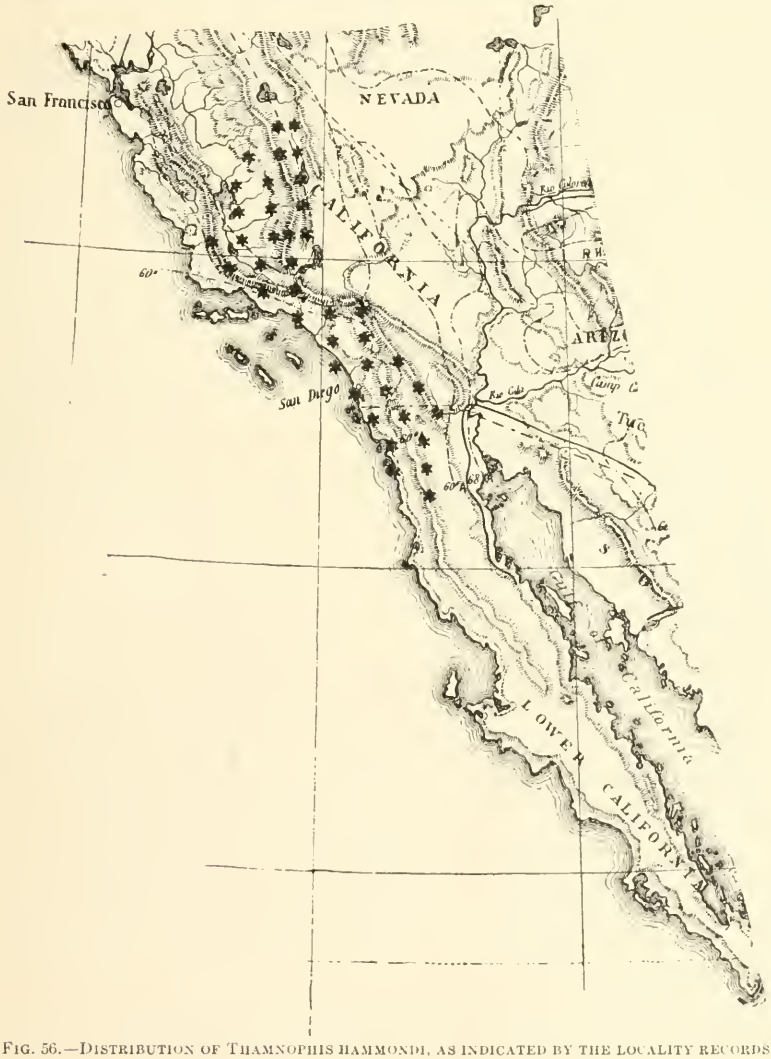


FIG. 56.—DISTRIBUTION OF THAMNOPHIS HAMMONDI, AS INDICATED BY THE LOCALITY RECORDS.

only from the mountainous region of southern California and northern Lower California, and what is known of its habits would indicate that it will not be found commonly in the desert region adjoining unless it be in the mountains[a] (fig. 56).

[a] The locality "Mohave Desert, Arizona," is too general to be relied upon.

Variation.—I have been able to examine but forty-four specimens of this form, and as the localities of these are scattered over the entire range the series from each locality is small. The material can not, therefore, be expected to yield definite information as to the extent and nature of the variations. Fortunately, however, the variation in most of the characters is slight. The dorsal scale formula is quite constantly 21–19–17 in every locality, the only variation observed being in the occasional occurrence of the formula 19–21–19–17 in specimens from localities representing every part of the range. The supralabials are 8 in every specimen examined, with the exception of one from San Diego County, which has 9 on one side. The infralabials are nearly as constant in number, as the only specimens in which the number departs from 10 are five, one from San Bernardino County, one from San Diego County, and one from Cartago, all of which have 11 on one side; one from Fort Tejon with 12 on one side, and one from the "South Fork of Kern River," which has 9 on one side. The labial formula is thus quite constantly 8/10 over the entire

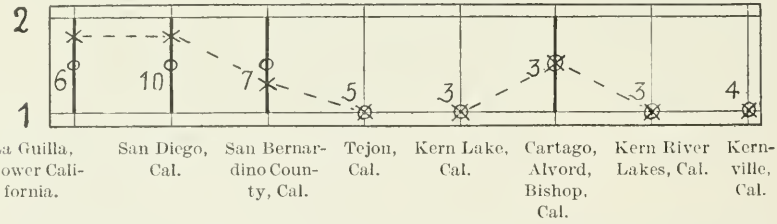


FIG. 57.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF PREOCULARS IN THAMNOPHIS HAMMONDI.

range, and much larger series are needed if there are any geographic differences to be revealed in either the labial or dorsal formulas.

As regards the preoculars the case is different. As previously stated, the number may be 1 or 2, and it is interesting to mention that in a number of specimens examined with 2 the two scales are partially fused, which seems to indicate further that the number of preoculars is intermediate. In the table that forms fig. 57 is shown the geographic distribution of this trait. This diagram seems to indicate that in the southern part of the range there is a decidedly greater tendency toward two preoculars than to the northward, a fact which, if true, is a significant one.

As far as can be determined from the material at hand the number of ventral and subcaudal plates and tail length exhibit no geographic differences, the limits being: Subcaudals, 65–81 (females), 71–96 (males); ventrals, 155–171 (females), 164–178 (males); tail length, about .21–.25 (females), .25–.27 (males). It is hardly necessary to point out that these limits, based as they are on a small amount of

material, will doubtless be corrected with more specimens, but they indicate the general conditions.

Affinities.—The possession by this form of two preoculars in the southern part of its range is very interesting, since it is in this region that it approaches nearest to the region inhabited by *angustirostris*, and the division of the preoculars (a rare trait in the genus) furnishes a strong inducement to consider its presence in both forms an evidence of direct relationship. The derivation of either of these forms from the other is not as improbable as it may seem at first sight, for they are closely similar, especially in the adjacent parts of their ranges. They have apparently the same number of dorsal, labial, ventral, and subcaudal scales and tail length, besides possessing in common the characters of more than one preocular and absence of the dorsal stripe. *Hammondi* differs from *angustirostris* in generally having two instead of three preoculars, the eye in contact with two labials, not well-defined lateral spots, and in the presence of stripes. Since *angustirostris* often has but two preoculars, and indeed apparently to the south grades into a form (*melanogaster*) which has but two, it is not impossible that the number also decreases in the northern part of the range. We have already seen that the other scale character (the separation of the eye from one labial) suffers a similar fate. The only apparent differences between *angustirostris* and *hammondi* that remain, then, are the presence of the stripes and the obscurity of the lateral spots. These differences are comparatively slight, but the fact that the dorsal stripe is nearly always wanting in *hammondi* renders the differences still less. In fact, in the general type of coloration as well as in the arrangement of the ocular scales, *hammondi* is similar to *melanogaster*, and I believe that there is strong evidence for concluding that *angustirostris* is genetically midway between these two forms.

Its resemblance to *angustirostris* decreases in the northern part of its range, and *hammondi* comes to resemble another form (*elegans*), which replaces it to the northward. Its resemblance to this form is so close that specimens from near the range of the latter (Inyo, Kern, Tulare, and Fresno counties, California) are distinguished with the utmost difficulty. This is brought about by the fact that *hammondi* usually has a single preocular in the northern part of its range and occasionally a dorsal stripe, and it can with certainty be distinguished from *elegans* only when it has either two preoculars or no dorsal stripe. However, sufficient proof that these forms actually intergrade is wanting. Their relations will be considered more fully when the affinities of *elegans* are discussed.

ELEGANS.[a]

Description.—On the high plateau region and in the Sierra Nevada-Cascade and Rocky Mountain ranges of North America occurs one of the best known and least well-defined forms in the genus. This form, as here understood, consists of the snakes usually referred to *vagrans* and in part also to *elegans, biscutata, infernalis,* and *lineolata.*[b] The lateral stripes are on the second and third scale rows, the dorsal usually on the median and a varying amount of the adjacent rows, being usually encroached upon by the spots of the upper series. Both dorsal and lateral stripes often indistinct, the dorsal occasionally absent for a part or all of the length. Dorsal scale rows, 21–19–17 or 19–21–19–17; labials, 7/9, 7/10, 8/9, 8/10, or 8/11; preoculars, 1 or 2; postoculars, 2, 3, or 4; subcaudals, 65–79 (females), 80–96 (males); ventrals, 152–169 (females), 163–182 (males).

The form is moderately robust, tail length about .18–.24 in females, .24–.276 in males, although these limits are rarely attained. Head distinct, eye small. Postgenials usually as short or shorter than the preceding pair, but occasionally longer. Two rows of alternating black spots on either side between the lateral and dorsal stripes, which are usually, although not always, distinct on the scales (see frontispiece). Nuchal blotches usually rather small, and generally interrupted by the lighter keels of the scales. Head brownish, often considerably marked with black. Labials only narrowly margined, if at all.

Habits and habitat relations.—The form apparently differs little from the other garter-snakes in preferring the proximity of water, either in the form of marshes, ponds, lakes, or streams. Various writers describe its habits as follows: Coues (1875, 614–615): "My specimens were found along the Zuni River in New Mexico wherever this stream spreads into sluggish lagoons, basking on the floating plants or swimming freely in the water like a Nerodia or Regina." Merriam (1891, 15): "Several garter-snakes (*Eutænia vagrans*) were found in the water in small, cold streams emptying into Salmon River a few miles north of Round Valley." Cope (of his variety

[a] *Thamnophis ordinoides elegans* (Baird and Girard), Catalogue of North American Reptiles, 1853, pp. 34–36. Includes *Eutænia vagrans* Baird and Girard, *E. biscutata* Cope, *T. vagrans biscutata* Van Denburgh (part.), *E. infernalis* Cope, *E. elegans lineolata* Cope, *E. elegans brunnea* Cope, *E. henshawi* Yarrow, *E. couchi* Kennicott, and *E. vagrans plutonia* Yarrow.

[b] My conception of this and the following form will appear strange to most herpetologists. A careful study of the material, however has shown that it is impossible to recognize the forms *vagrans, elegans, lineolata, atrata, leptocephala, trilineata,* and *biscutata* as they are usually defined. In fact a perusal of the literature will show that no two writers are agreed as to the importance of the several forms that have been described.

biscutata): "This species is not uncommon in the swamp vegetation on the borders of the lake" (fig. 58). A series of specimens sent to me from Flathead Lake, Montana, were taken on the shore of the lakes and in neighboring swamps. I can find nothing on the food habits of this garter-snake, but in view of these habitat notes it is probable that frogs and fish form an important part of the food of the

FIG. 58.—HABITAT OF THAMNOPHIS ORDINOIDES ELEGANS. KLAMATH MARSHES, SOUTHERN OREGON.

individuals found in these habitats. While, however, *elegans* thus apparently prefers an aquatic habitat, it is probably not strictly confined to the vicinity of water except in the more arid regions. This conclusion is borne out by the fact that a specimen in the U. S. National Museum from Boulder County, Colorado, is labeled "bare

rocky hill," and from the stomach of another from Conejos, Colorado, I removed the remains of a field mouse (badly flyblown). Proof that it is not an arid type is again found in the fact that it is found at considerable altitudes (8,500 and 10,000 feet) in the forest zones. (See list of localities below.)

Range.—Elegans has a very extensive distribution. At the present time it is known to extend from the western margin of the great plains, in eastern New Mexico and Colorado, and western Nebraska, South Dakota, and central Montana, westward through the Rocky Mountains and high plateau regions to the west slope of the Sierra Nevada and Cascade ranges, and from the southern margin of the high plateau in New Mexico and Arizona to southern Canada. As detailed notes on distribution are not available, a general description of the environmental conditions of the range will be sufficient. The whole region consists of numerous mountain ranges, rising from lower plains which have an altitude of 5,000 to 8,000 feet, although on the Columbia River lava plains, Snake River plains, and about Great Salt Lake the elevation is lower. The mountains receive most of the rainfall, and support extensive forests on the higher elevations, while the plains, owing to the scanty precipitation which they receive, are arid and support a more xerophytic flora, which varies with the intensity of the conditions. The region is limited by lower elevations, on the east by the high plains, on the south by the proplateau, which extends far northward in western Nevada, and on the west by the interior valleys of California and Washington and Oregon. In southern and northern California and southern Oregon, however, it reaches the coast, as elevated areas here connect the Sierra Nevada-Cascade and coast ranges.

Specimens have been examined from the following localities: Sapello Canon (altitude 10,000 feet), San Miguel County, Chico Springs, Albuquerque, Albiquiu, Taos, San Ildefonso, Willow Springs, San Juan River, Cantonment Burgwyn, Fort Wingate, Fort Garland, San Francisco Mountains, New Mexico; Conejos, San Luis Valley, Rio Grande, Durango, Pagosa, Boulder County (altitude 9,500 feet), Gypsum, Grand Junction, Twin Lakes, Hayden, Colorado; Black Hills, Dakota; Bozeman, Fort Benton, Fort Custer, Flathead Lake, Billings, Cache Le Poudre Creek, Fish Creek, Swan Lake, Helena, Montana; Yellowstone Park, Fort Laramie, Fort Fetterman, Wyoming; Vernon, Sicamous, Nelson, Bear Lake, Rocky Mountain Park, British Columbia; Lewiston, Ketchum, Fort Hall, Idaho; Pyrmont, Camps 10 and 12 (Ridgway), Snake Valley, Silver Creek, Lake Tahoe, Ash Meadows, Nevada; Fort Bridger, Juab, Rattlesnake Mountain, Copenhagen, Ogden, Utah; Fort Whipple, Fort Verde, San Francisco Mountain, Mineral Spring, Prescott, Arizona; Horse Corral Meadows, Humboldt Bay and Humboldt River, Tenaya Lake Meadows, Eagle

Lake, Camp Bidwell, San Joaquin River (altitude 8,100 feet), Eldorado, Kern Lake, Kern River, Mount Whitney, North Fork Kern River, Whitney Creek (Crab Tree Meadow), Whitney Creek (9,000 feet below Whitney Meadows), Mount Whitney (Hot Springs, altitude 8,000 feet), Owens Valley, Lone Pine, Owens River (altitude 6,000 feet), Morro, Baird, Pit Canyon, California; Goose Lake, between Warner and Goose Lakes, Fort Klamath, Klamath Lake, Camp Warner, Dallas, Oregon; Fort Walla Walla, Washington.

If *elegans* were generally distributed over the region in which it is found its range of habitat could scarcely be exceeded in the western half of the North American continent, as the region which it inhabits includes on the one hand the arid plains of the Proplateau region, and on the other the snow-capped peaks of the Rocky and Sierra Nevada-Cascade ranges, but, although the data at hand on the habitat distribution of the form is very meager, evidence is not wanting that it is not of general distribution in the region which it occupies. From what is known of its habits it is not surprising to find that the range of *elegans*, as shown by the above localities, is principally confined to the higher elevations, where there are perennial streams. The probable limits of its range can thus be discussed.

As it is found on the Proplateau in southern Nevada, it may be found on the mountain ranges of the same feature in southern Arizona, New Mexico, and Texas. Van Denburgh (1897, 211) writes that it "is known to live on both slopes of the Sierra Nevada throughout the whole length of the chain." I believe this to be true, although not in the sense meant by Van Denburgh, for we must include specimens formally referred to *elegans* in order to establish its presence on the west side of the Sierra Nevadas. It has been recorded several times from east of the high plateau region, but none of these records are trustworthy. The specimen found at Chicago,[a] while undoubtedly an *elegans*, unquestionably reached there accidentally.

Taylor (1892, 326) records specimens from Gage, Nemaha, and Sheridan counties, Nebraska, but these localities are so much farther east than any other authentic records for the form that they must be seriously questioned until confirmed. Branson (1904, 366) states that "this snake is quite rare in the western part of Kansas. None have been reported from the eastern part." As he gives no localities, however, and I have neither seen a single specimen from this State, nor know of an authentic record, I consider the specimen from Colorado as representing the known eastern limit of the range of *elegans* in this latitude; the more so as the western border of Kansas is some distance east of the contour line of 5,000 feet, which may be considered as marking the eastern boundary of the high

[a] Compare Ruthven, 1904, 291.

plateau region. At the present time, therefore, *elegans* is not definitely known to occur east of this region, although it may occur to some extent along the streams on the great plains immediately

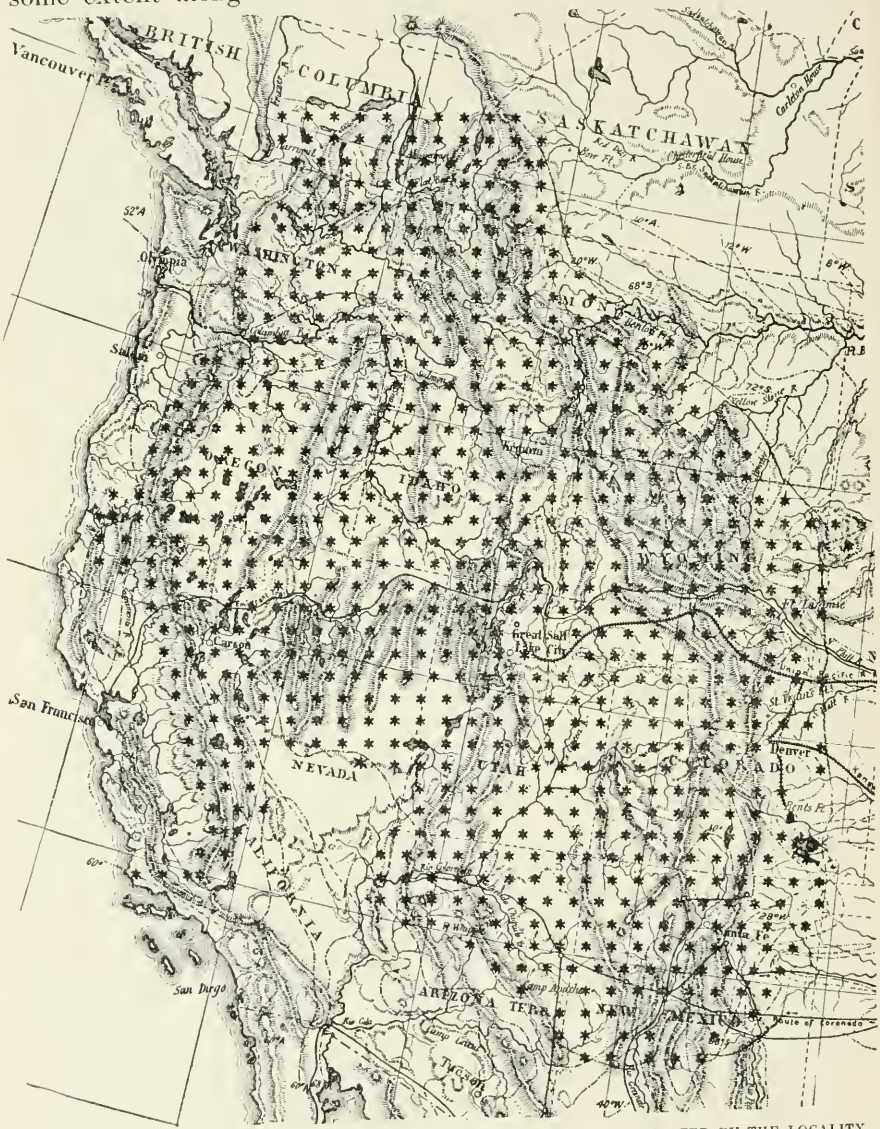


FIG. 59.—DISTRIBUTION OF THAMNOPHIS ORDINOIDES ELEGANS, AS INDICATED BY THE LOCALITY RECORDS.

adjoining, as will be shown later. Thus, Coues (1878, 275) found in Montana that:

> The wandering garter-snake does not appear to be generally distributed along the northern boundary line. It was not met with during the first year of my connection with the survey in any part of the Red River watershed, nor was it seen the second season except to the westward from the main outliers of the Rocky Mountains to the main chain itself.

As will be seen later, its western limit can not be drawn exactly owing to the fact that it intergrades with another form on the Pacific coast, but if specimens with a scale formula of not less than 19–21–19–17 are considered *elegans*, it is found to the foot of the Sierra Nevada-Cascade range on the west side, throughout the length of the chain, bending westward in the mountainous region of northern California to the coast. The range, as far as it is definitely known at present, is shown on the accompanying map (fig. 59).

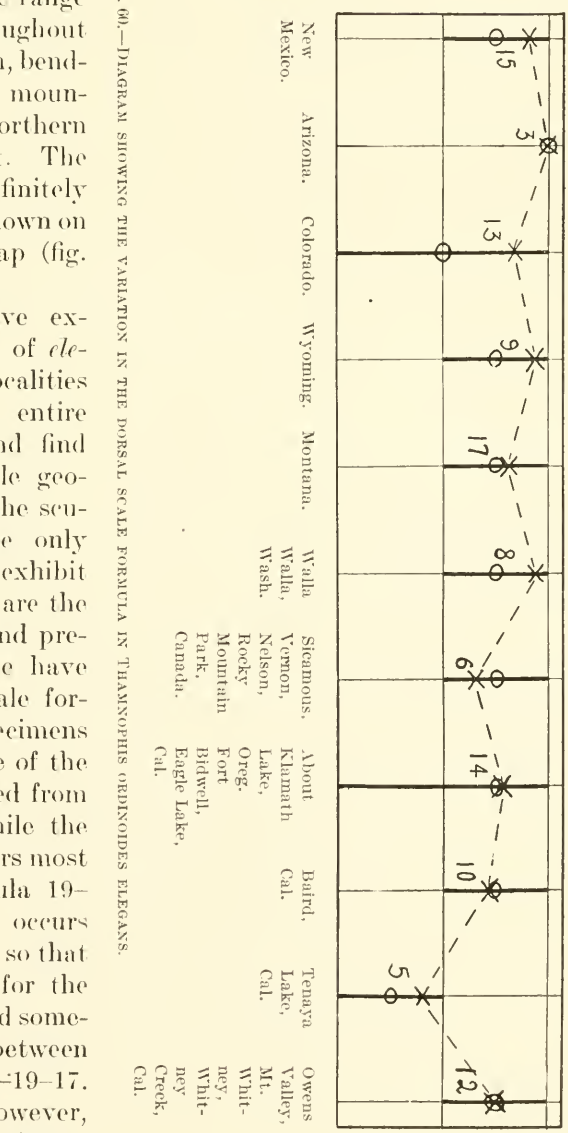


FIG. 60.—DIAGRAM SHOWING THE VARIATION IN THE DORSAL SCALE FORMULA IN THAMNOPHIS ORDINOIDES ELEGANS.

Variation.—We have examined 218 specimens of *elegans* from various localities scattered over the entire range of the form and find that there is very little geographic variation in the scutellation. In fact the only two characters that exhibit geographic differences are the dorsal scale formula and preoculars. In fig. 60 we have plotted the dorsal scale formula for suites of specimens representing the range of the form. It will be noted from this diagram that while the formula 21–19–17 occurs most frequently, the formula 19–21–19–17 apparently occurs throughout the range, so that the average formula for the form may be considered somewhat intermediate between 21–19–17 and 19–21–19–17. It will be noticed, however, that in western specimens (from British Columbia and in the Sierra Nevada-Cascade range)

there is apparently a greater tendency toward a smaller formula than 21–19–17 than elsewhere in the range. This reduction is a real one, and it takes but little familiarity with the material to bring out the fact that there is a reduction in the number of scale rows all along the western boundary of the form (see map, fig. 59). It is in part owing to this fact that the number of scale rows of *elegans* (in the old sense) has been so frequently a disputed subject.

The supralabials are nearly always 8, but in nearly every locality, irrespective of its place in the range, one or two specimens have 7 upon one or, more rarely, both sides, but 9 plates are so rare that we have seen but one specimen which had this number and then only on one side. Likewise the number of infralabials, while 10 in the great majority of specimens, is occasionally 9 and much more rarely 11. In fact the average formula for every locality where a considerable number of specimens have been examined is never higher than 8/10, and very often about 7.8/9.8, thus indicating that the form tends to have a smaller formula than 8/10. No geographic differences can be observed.

As in the case of the labials, the material shows no geographic differences in the ventral and subcaudal scutes and tail length. The

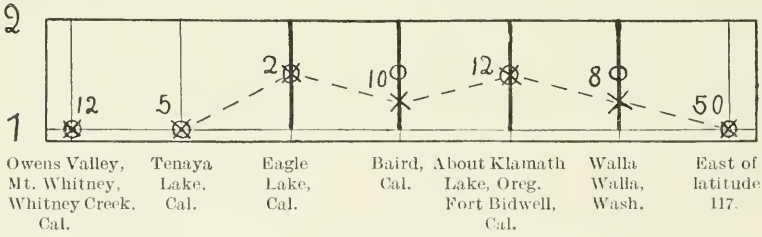


FIG. 61.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF PREOCULARS IN THAMNOPHIS ORDINOIDES ELEGANS.

sexual variations are as follows: Ventrals, 152–169 (females), 163–182 (males), average about 169; subcaudals, 65–79 (females), 80–96 (males); tail length, .18–.24 (females), .24–.276 (males).

Over the greater part of its range *elegans* has but a single preocular. As Cope (1883, 21–22) first pointed out, however, certain garter-snakes from southeastern Oregon have two scutes in this series. Cope made this trait the basis of a distinct species (*biscutata*), but the likeness of these snakes to *elegans* (*vagrans*) were recognized by Brown (1901, 23–24) and Van Denburgh (1897, 212), and they were classed as a subspecies of *elegans* (and *vagrans*).[a] As this is the only character by which these snakes differ from typical *elegans*, and it is far from being constant in this region, it is absurd to attempt to distinguish a distinct subspecies on this basis. Nevertheless the occurrence of two preoculars in the form is interesting. In the diagram (fig. 61) I have plotted the distribution of the trait, and there is shown to be a strong tendency toward divided preoculars in northern

[a] Under the name *biscutata*, Brown and Van Denburgh also included with these *elegans* specimens individuals of *ordinoides* with two preoculars.

California and east central Oregon and Washington. At first sight the localities in which two preoculars occur seem to represent an isolated region, but, as will be shown later, I believe that the trait outcrops all along the western boundary of the range (in the Sierra Nevada-Cascade range) from the southern limit in the mountains of southern California to the northern limit in British Columbia.

Elegans is quite constant in coloration over most of its range. The following description holds for most of the specimens east of the Sierra Nevadas: Ground color light brownish olive, relieved by two rows of rather small black lateral spots that usually occupy only the edge of the scales; stripes yellow, tinged with orange or green, the laterals upon the second and third rows and frequently nearly indistinguishable from the first row of scales which is lighter than those above, the dorsal upon the median and more or less of the adjacent rows being nearly always encroached upon to the median row by the superior row of lateral spots; narrow bars at the base of the ventral scutes that may or may not be enlarged at the ends to form small spots and in the middle to make an irregular median ventral band.

In the Sierra Nevada-Cascade range the color tends to become generally darker, although the pattern of eastern specimens is retained. Such individuals have been distinguished by Cope (1892, 654–655) as *lineolata* and *brunnea*, but an examination of the types as well as many other specimens from the same region shows that they differ in no way from typical *elegans* except in the darker ground color, which obscures the lateral spots on the scales. In his description Cope states that in the type of *brunnea* there is not the least trace of lateral spots. This is not true, as they are easily seen on the skin when it is stretched. Specimens do occur on the west slope of the Sierras, however, in which the spots are mostly fused on the skin. This dark color is frequently accompanied by an increase in the width of the dorsal stripe, a tendency which in *elegans* occurs only in this region, but, as I shall show later, becomes of general occurrence to the westward. Such a specimen was described as *elegans* by Baird and Girard in 1853, but that the combination of characters can not be distinguished even as a subspecies is quite evident, as all intermediate stages occur between it and the dark (*lineolata* or *brunnea*) specimens of *elegans* in the Sierra Nevadas, while the scutellation is identical.[a]

Occasionally the dorsal stripe is nearly or quite obsolete, as in *hammondi*. Such a specimen was described by Kennicott as *E. couchi*. Some writers have considered these specimens identical with *hammondi*, but all variations in the width of the dorsal stripe occur, and it is evident that its total or partial obliteration is merely a variation.

[a] It is true that Baird and Girard gave the number of dorsal rows of the type specimen of *elegans* as 19, but these were evidently counted on the anterior part of the body alone, for the formula is 19–21–19–17, as in many specimens of *elegans* (*vagrans*).

Yarrow's (1883, 152) subspecies *plutonia* was based on melanistic specimens, as were also those which he (1875, 554) referred to *E. vagrans angustirostris* (Kennicott) and *E. henshawi* Yarrow (1883, 152). Melanism is more than usually common in the form. It is of interest that three specimens (No. 1133) in the Field Museum of Natural History from Grand Junction, Colorado, are all melanistic, and correspond closely to those listed by Cope as *plutonia*. As far as our present knowledge goes, the only definite geographical variation in color is an increase in black pigment in the Sierra Nevada-Cascade individuals, and a tendency toward an increased width of the dorsal stripe on the west slope of the Sierra Nevadas.

Affinities.—I have already stated that I believe *elegans* to be directly related to *hammondi*, which it meets in southern California. There are no apparent differences between the two forms which insure a certain distinction of the specimens in the intermediate region. The reason why some writers have insisted upon the distinctness of the two forms is because they have generally laid stress upon a single character in diagnosing their specimens. It has already been shown that although *hammondi* is usually characterized by 21–19–17 dorsal scale rows, two preoculars, the absence of a dorsal stripe, and no definite spots on scales, in the northern part of its range 19–21–19–17 scale rows, one preocular, and a dorsal stripe often occur; while *elegans* in the same region may have either 19–21–19–17 or 21–19–17 dorsal rows. The reason why *elegans* apparently does not exhibit two preoculars and an obsolete dorsal stripe in the southern part of its range may very well be due to the fact that specimens with these traits are referred to *hammondi*.

The fact that the characters may seemingly occur in any combination in the intermediate region leads one to suspicion that an intergrading actually takes place, and that the differences between the specimens are individual and not racial. However, this controvertible point can not be decided until a large series of specimens with detailed habitat notes has been obtained from the intermediate region. But whether or not intergrading occurs, I believe that there can be little question that the two forms are directly related. This belief is confirmed by the reduction in the number of scale rows in *hammondi* toward that part of the range of *elegans* with which it comes in contact and by the fact that it is only in the western part of its range that *elegans* possesses two preoculars. I have already called attention to the fact that in the Sierra Nevada-Cascade range *elegans* often has two plates in front of the eye, so frequent a trait in *hammondi*, and it is only necessary to note here that if *elegans* has been derived from *hammondi* the resemblance of the former to the latter should be the strongest along this range, as it is a highway for moisture-loving forms from southern California northward. If this explanation is the true one, the Sierra Nevada-Cascade range may

be considered as the center of dispersal for *elegans*, a fact that explains the wider separation of the high plateau and Rocky Mountain individuals of *elegans* from *hammondi* as shown by the fact that the former apparently never have two preoculars. The hypothesis may be further tested by examining the Pacific coast form of this group.

I have already referred to the fact that *elegans* apparently tends to become reduced as to the number of scale rows on the western slope of the Sierra Nevada-Cascade ranges. This reduction is hardly to be detected when true *elegans* specimens (those with 19–21–19–17 or 21–19–17 rows and from the slope of the mountains) are alone considered, but when those from the foot of the mountains are considered the reduction is strikingly evident. So pronounced is this that in the interior valleys between the Sierra Nevada-Cascade and the coast ranges from British Columbia to Kern County the form becomes transformed into another (*ordinoides*), with a dorsal scale formula as small as any in the genus. This subject will be reverted to in the discussion of the next form, and it is only necessary to point out here (1) that the intergradation between the two forms is perfect, and (2) that it takes place rapidly. Material is not available to fix the limits of the intermediate region, but, as shown by the distribution of the two forms, it may be placed tentatively as the long westward slope of the Sierra Nevada-Cascade range. It should be noted further, however, that specimens from this intermediate region (Fresno and Oakland, California) also exhibit occasionally two preoculars, as does also true *ordinoides* (see p. 152), thus showing that the trait occurs quite close to the range of *hammondi*.

The average number of ventrals is about 169, even in northern New Mexico and Arizona, where it approaches the range of *marcianus*. This, with the smaller dorsal scale formula, seems to us to indicate that *elegans* has been derived from some form with a larger number of ventral plates than *marcianus*, in which the average number falls between 155–160.

ORDINOIDES.[a]

Description.—West of the Sierra Nevada-Cascade range, in California, Oregon, and Washington, there occurs a form of garter-snakes that has caused herpetologists considerable embarrassment. As here

[a] *Thamnophis ordinoides* (Baird and Girard), Proc. Acad. Nat. Sci. Phila., 1852, p. 176. Includes *E. leptocephalus* Baird & Girard, *E. cooperi* and *E. atrata* Kennicott, *E. elegans vidua* Cope, *T. rubristriata* and *T. leptocephalus olympia* Meek, and in part the *E. elegans infernalis*, and *E. biscutata* of various authors, but not of the original describers. It seems that most writers have been uncertain as to just what form this name should apply. This uncertainty has been brought about by the description of the form given by Baird and Girard in 1853 (1853, 33–34), which applies equally to *parietalis*, *elegans*, and the present form, and indeed of the three specimens listed the first is a *parietalis*, and the second a specimen of the present form with 21–19–17 rows. These specimens are labeled types of *ordinoides*, but it should be recalled that *ordinoides* was described in 1852 and on the basis of a specimen from

understood, *ordinoides* includes the following described forms which are recognized by different writers at the present time: *elegans, atrata, biscutata* (part), *leptocephala*. It will seem strange to some herpetologists that I have defined this form as I have, but if the published writings are indicative, no two of the present day authorities will agree as to just which ones it should include, and this very diversity of opinion is an evidence of the close resemblance that exists between the several forms that are usually recognized.

The lateral stripe is frequently absent, but when present is always upon the second and third rows, and usually grayish or yellowish in color, frequently red for more or less of its entire length. The dorsal stripe is apparently always present except in melanistic individuals and is usually well defined, not being encroached upon by the upper series of lateral stripes. It may be one, one and one-half, or three scales in width, and pale yellow, bright orange yellow, or red in color. The form is very variable. The scale rows may be 21–19–17, 19–21–19–17, 19–17, 17–19–17–15, 17–15, 15–17–15, but are usually 19–21–19–17 or less. The supralabials are usually 8, often 7, occasionally 6; infralabials 7, 8, 9, or 10, rarely 11 or 12. The oculars are usually 1–3, often 1–2, occasionally 1–4, frequently 2–3 or 2–4, rarely 3–3. Unfortunately I have not been able to examine the sex of a sufficient number of individuals to determine, even in a general way, the limits of sexual variation in the number of subcaudals and ventrals. The individual variation is, however, very great. The extremes are: Ventrals, 132 (female)–172 (male); subcaudals, 55 (female)–91 (male). Chin shields short, subequal, or nearly so. Eye small.

There is no single well-defined type of coloration, but the form may generally be known by the following description: The ground color of the dorsal scales may be black, brown, dark or light olive, with or without small lateral spots. The skin may be either marked by two distinct rows of black spots with light interspaces or be mostly black with small, irregularly disposed areas of lighter. The interspaces on both skin and scales frequently considerably suffused with red. The belly is generally some shade of olive or yellow, frequently spotted with red in the middle. Head olivaceous, brownish or black.

Habits and habitat relations.—I know of no recorded observations on the habits or habitat of this snake.

Range.—As above defined, *ordinoides* is known to inhabit in a general way the region lying between the Sierra Nevada-Cascade range and the Pacific Ocean, extending from the Tehachapi Moun-

Puget Sound. Although we have not been able to find the type, the original description is perfectly clear, and two characters mentioned therein—two preoculars and two distinct rows of spots—shows conclusively that the description was based on a specimen of the western form described again in 1853, and since then known as *leptocephalus*. The name *ordinoides* thus takes precedence over *leptocephalus*. I am not certain of the identity of *Coluber infernalis* Blainville.

tains, California, on the south to southern British Columbia on the north. I have examined specimens from the following localities: Monterey, Oakland, Fresno, San Francisco, Nicasio, San Pablo Creek, Eureka, Mendocino, Santa Cruz County, Crescent City, California; Willamette Valley, Chilowyuck, Gold Beach, Fort Umpqua, Astoria, Portland, Oregon; Tahot plain, Shoalwater Bay, Chalahapa, Attlapootl, Port Orchard, Fort Townsend, Olympic Mountains (30 miles from Port Angelus), Puget Sound, Seattle, Fort Steilacoon, Tacoma, Washington; and Comox Lake, Victoria, Vancouver Island. While its distribution is quite definitely limited on the north and west, I believe that it is impossible to fix the exact eastern and southern boundary of *ordinoides* for the reason that it intergrades with *elegans* throughout the entire length of its range. If I am correct in this opinion, there remains to be established the region of intergradation of the two forms. Van Denburgh (1897, 209, 211) has recorded specimens from as far east as Tuolumne Meadows (Tuolumne County), Yosemite Valley (Mariposa County), Lake Tahoe (Placer County), and El Dorado County, California, and writes that *vagrans* (*elegans*) "is known to live on both slopes of the Sierra Nevada throughout the whole length of the chain," in which case the ranges of the two forms would overlap. As previously stated (pp. 140–141), I have examined specimens similar to those usually referred to *elegans* from El Dorado, Mariposa (Tenaya Lake Meadows), Tuolumne (Tuolumne Meadows), Placer (Lake Tahoe), and Shasta (Baird) counties, California, and Dalles, Oregon, and prefer to consider them all as belonging to *elegans* (*vagrans*); while true *ordinoides* only occurs in material from the base of the mountains and to the westward. It is impossible, however, at present to draw the exact line along which these forms intergrade, both owing to the lack of specimens and to the uncertainty of the exact locality from which the specimens that we have were taken. As has been elsewhere stated, collectors are too prone to label their material with the name of the nearest conspicuous landmark, although the latter may be miles distant. Thus, a series of specimens "from a collector at Oakland" (Brown 1903, 289) are evidently intermediate, but they cannot be used, as we do not know the exact part of the county from which they came.

For the present, therefore, we can only say that *ordinoides* meets *elegans* somewhere on the lower level of the western slope of the Sierra Nevada-Cascade range, but if the former be distinguished from the latter, as we have indicated above, by a more reduced scutellation, and the frequent increased width of the dorsal stripe, we may consider specimens from Stockton, Fort Reading, and Dalles, as intermediate between the two forms.

As might be expected, the range of *ordinoides* is nearly divided in northern California and southern Oregon by the mountainous

district that here bridges the gap between the Sierra Nevada-Cascade and coast ranges. That *elegans* pushes westward in these mountains nearly to the coast is shown by specimens from Baird, Shasta County, and several specimens in the U. S. National Museum labeled "Humboldt River" and "Humboldt Bay, California." From the latter records it might seem that *elegans* reaches the coast in this region, but since specimens from Eureka in the Field Museum are

FIG. 62.—DISTRIBUTION OF THAMNOPHIS ORDINOIDES, AS INDICATED BY THE LOCALITY RECORDS.

true *ordinoides*, as well as some of the Humboldt Bay specimens in the U. S. National Museum, the conclusion is justified that all of the specimens in the latter series were not taken in the immediate vicinity of the bay, the *elegans* individuals probably having been taken in the mountains to the eastward. The known range of the form is indicated on the map (fig. 62).

Variation.—The dorsal scale formula of *ordinoides* is generally small, as shown by the accompanying diagram (fig. 63). The

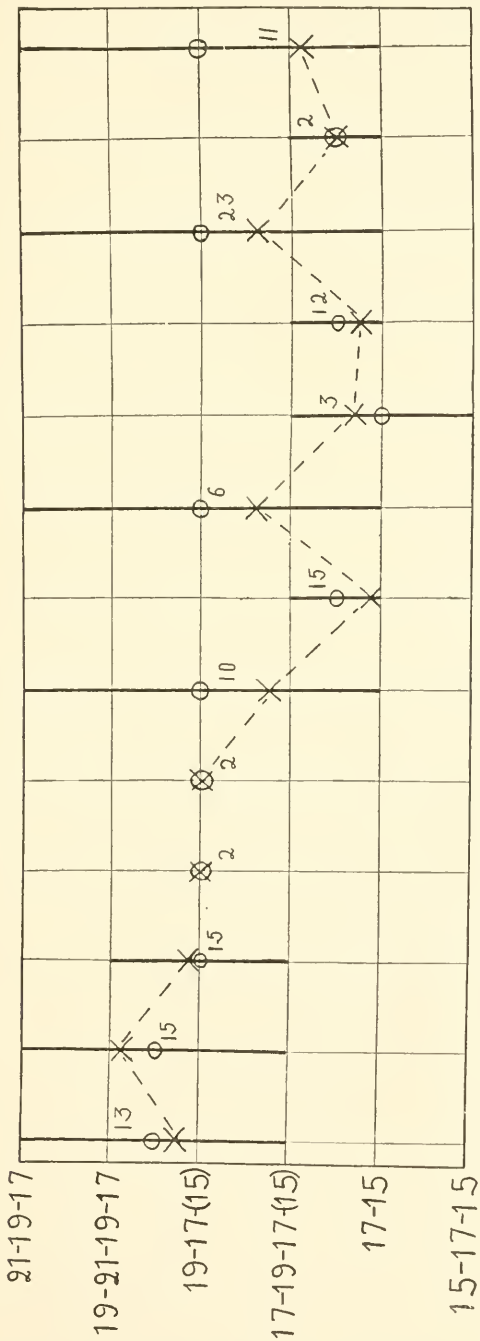


FIG. 63.—DIAGRAM SHOWING THE VARIATION IN THE DORSAL SCALE FORMULA IN THAMNOPHIS ORDINOIDES

diagram further shows that there is a considerable range of variation in this character, the extremes approximating those for the genus,

for the formula 15–17–15, occasionally exhibited, is the lowest, while the highest, 21–19–17, is next to the highest in the genus. The averages, however, reveal a most pronounced tendency toward a formula less than 19–21–19–17. The average formula for California specimens south of Eureka, California, is about 19–17, while north of this point in California, Oregon, and Washington the average for different localities falls between 17–19–17–(15) and 17–15, although in the Puget Sound series the mean approaches 19–17.

The variability of the dorsal scale formula is paralleled in the labials. Thus, the supralabials may be 6, 7, or 8, the infralabials 7, 8, 9, or 10. When the averages are taken, however, (figs 64–65), the formula is seen to be reduced. This is less noticeable in the case of California specimens from localities south of Eureka, in which the average is nearer 8/10 than a lower formula, but north of Eureka, as shown by the table, the frequent occurrence of 6 supralabials and 7 or 8 infralabials draws the mean number of supralabials down to about 7, and that of the infralabials between 8 and 9, the number in both series being slightly higher in the series from Puget Sound.

The ventral and subcaudal scutes are also variable, so much so, indeed, that in view of the limited number of specimens examined we can only expect approximate results in the averages. When the larger series are plotted (figs. 66–67), however, the results are strikingly similar to those of the dorsal and labial scutes. Thus, the mean number of ventrals for localities south of Eureka is between 156 and 162, the subcaudals between 76 and 83, while north of Eureka the average number of ventrals lies between 143 and 152, subcaudals between 61 and 70. Again, in the case of these scutes the number in Washington specimens is highest in the Puget Sound specimens. That the variation in the number of subcaudals is not due to a variation in proportionate tail length is shown by the fact that the latter exhibits no apparent differences throughout the range, and is evidently very nearly, if not exactly, the same as in *elegans*. In the present material the length of the tail varies from .215 (female) to .28 (male), the averages for different localities being between .23 and .26.

Even from the few specimens that it has been possible to examine, the above tables show that *ordinoides* as a form is strikingly dwarfed and that the specimens from the localities north of Eureka and toward the coast tend to have fewer dorsal scale rows, labial plates, ventral and subcaudal scutes than those south of Eureka and toward the Cascade range in Washington. From the present data (fig. 68) *ordinoides* may have either one or two (rarely three) preoculars. From the table it may be seen that the usual number is one and that the occurrence of two preoculars is only occasional. However, the

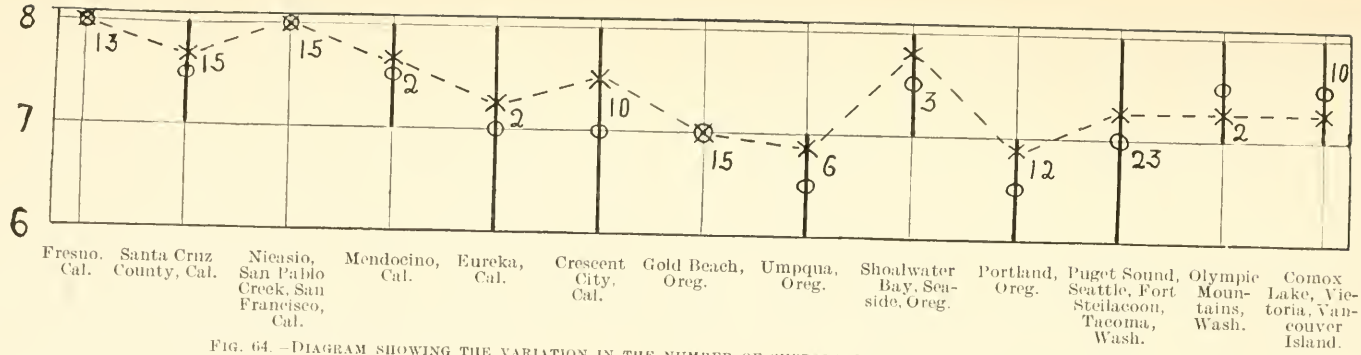


FIG. 64.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS ORDINOIDES.

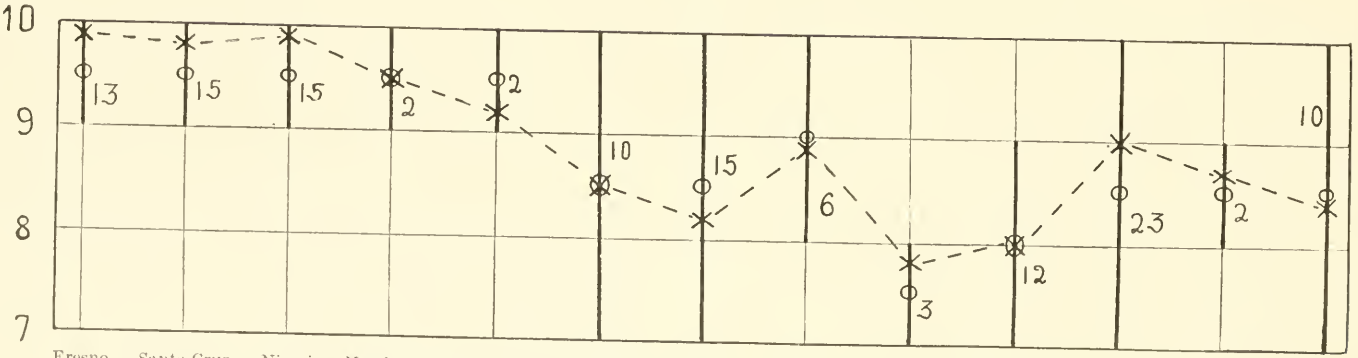
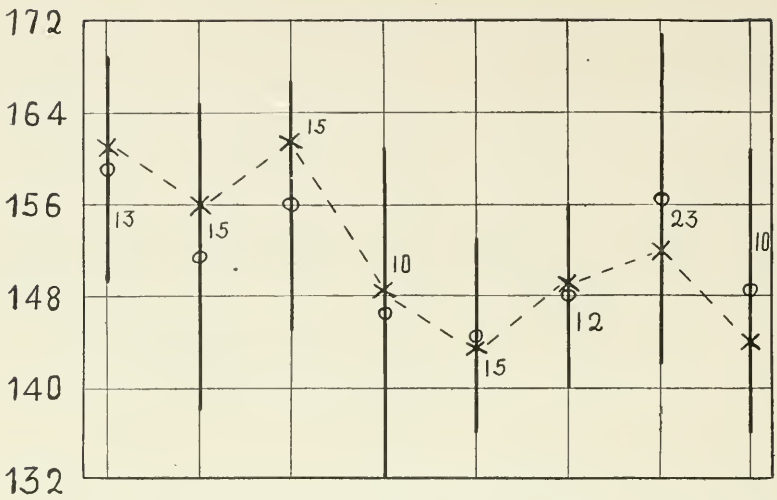
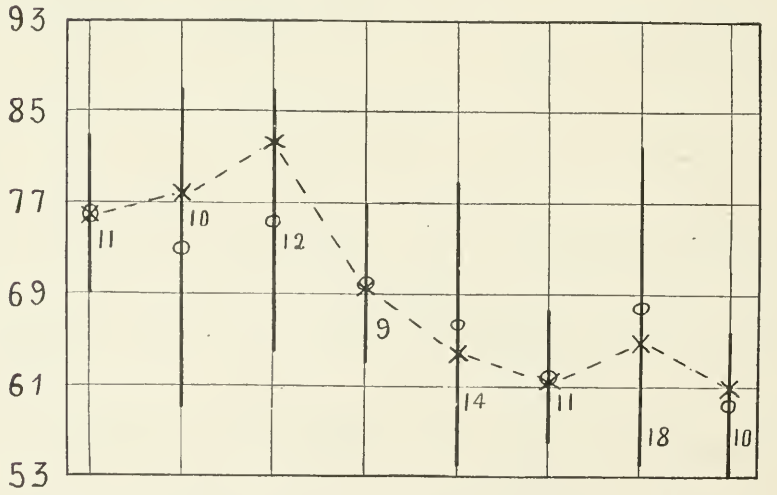


FIG. 65.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF INFRALABIALS IN THAMNOPHIS ORDINOIDES.



Fresno, Cal. | Santa Cruz County, Cal. | Nicasio, San Pablo Creek, San Francisco, Cal. | Crescent City, Cal. | Gold Beach, Cal. | Portland, Oreg. | Puget Sound, Seattle, Fort Steilacoon, Tacoma, Wash. | Comox Lake, Victoria, Vancouver Island.

FIG. 66.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF VENTRAL SCUTES IN THAMNOPHIS ORDINOIDES.



Fresno, Cal. | Santa Cruz County, Cal. | Nicasio, San Pablo Creek, San Francisco, Cal. | Crescent City, Cal. | Gold Beach, Cal. | Portland, Oreg. | Puget Sound, Seattle, Fort Steilacoon, Tacoma, Wash. | Comox Lake, Victoria, Vancouver Island.

FIG. 67.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUBCAUDAL SCUTES IN THAMNOPHIS ORDINOIDES.

proportionate number of western Washington specimens with two is greater than in the series from elsewhere in the range, while none of the California specimens exhibit more than one except those from Fresno which have two. It should be stated, however, that two out of seventeen "intermediate" specimens from "Oakland" also have two. Just what this means is difficult to determine, but it is interesting to note that the latitudinal variation in the frequency with which the trait—two preoculars—occurs in *ordinoides* is exactly the same as in *elegans*. For some time writers have been led by the occurrence of this trait to adopt one of two courses: (1) To separate the forms with two preoculars and class them with similar specimens of *elegans* as a distinct form (*biscutata*); (2) to credit the form with having both a single or a double preocular. The first view is untenable, since the specimens with two preoculars are identical with those with one, from the same region, while, as I have shown, the western specimens differ markedly in scutellation from the eastern examples. As I have indicated under the discussion of *elegans*, reliance can not be placed on this character as a diagnostic one, and I believe that the evidence of the other characters shows conclusively that in *ordinoides*, as along the western border of the range of *elegans* and in the intermediate region between the two forms, the occurrence of two preoculars is to be considered as an occasional variation.

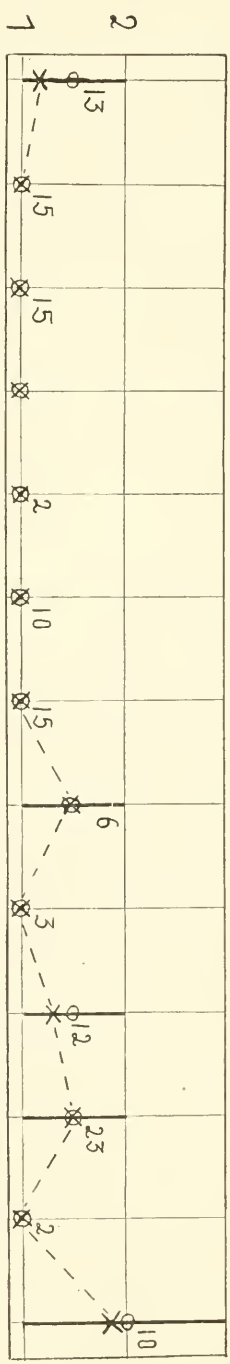


FIG. 68. DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF PREOCULARS IN THAMNOPHIS ORDINOIDES.

The color is variable, and so much so that it is difficult to determine to what extent the differences are geographic. Nevertheless I believe that the material at hand indicates a generally paler color in the

specimens from the most western (coast) localities. The most usual color is brown with red markings on the scales; stripes greenish, yellowish or red, the lateral on the second and third rows, the dorsal on more or less of the median three.[a] On the coast in California, however, specimens are found that have a light olive ground color, no lateral spots visible on the scales, lateral stripes wanting, and a wide, yellow, dorsal stripe. This lighter color phase thus accompanies the reduced scutellation, a fact which has several times led to the description of such specimens as separate species or subspecies (*atrata* Kennicott and *vidua* Cope). They are, it is true, rather unique with their light color and reduced scutellation, so that, ignoring the variations in these characters, they might easily be considered distinct. Brown's hypothesis that such individuals represent mutations is perhaps excusable on this ground, but with the series before me I can see absolutely no reason for considering them distinct. In the first place, all gradations occur in the same locality between so-called *atrata* specimens, with no lateral stripes and a uniform ground color of pale olive, and darker specimens with distinct lateral stripes, while in the second place a tendency toward the same coloration is evident along the western coast from Santa Cruz County, California, to the Olympic Mountains in Washington. Van Denburgh (1897, 209) states that such specimens occur "nowhere else but on the coast slope of the San Francisco peninsula." That this is a mistake is shown by an apparently typical example from as far north as Crescent City, California, in the Field Museum. This specimen is a typical "*atrata*" except that the dorsal stripe is red and rather narrower than usual. It is true that no typical "*atrata*" specimens have been found in Oregon and Washington, but this may be attributed to the fact that the specimens from this general region are, as a rule, very dark, nevertheless the two Mount Olympic specimens in the Field Museum, described by Meek (1899, 235–236) as *leptocephalus olympia* and *rubristriata*, approach very closely to this type of coloring in being uniformly olive and having the stripes indistinct or wanting.

As a rule, however, the ground color of the Oregon and Washington specimens are darker than those from California. At first sight this fact, together with the reduced scutellation of the former, might seem to indicate that we are here dealing with two forms, but as the differences between the two sections are slight, of degree only, and far from constant, I can not consider them sufficient grounds for dividing the form as I understand it.

Affinities.—Owing to the position of the lateral stripe upon the second and third rows, *ordinoides* can be classed only with the *Sirtalis*

[a] This is the *T. infernalis* of Baird and Girard, Cope, and later writers. The red may also occur in the specimens which are intermediate between *elegans* and *ordinoides*.

or *Elegans* groups. I believe that I have proven conclusively in the discussion of the two forms that *ordinoides* and *elegans* are not only closely related but that they actually intergrade. This relationship has been more or less recognized as far as the California (*elegans*) section of the former is concerned for a considerable number of years, but the Oregon and Washington section has often been considered as a distinct species. To class this part of the form with *sirtalis*, as has been done several times, for the reason that the two forms agree in having 19 scale rows and 7 supralabials, is absurd. In the first place, *the recognized members of the Sirtalis group in this part of North America never have more nor less than 19–17 scale rows, 7 supralabials and one preocular, while ordinoides exhibits both more and less than this number of scale rows, and frequently more than one preocular, so that, while the latter is evidently a dwarfed offshoot of some form, the parent stock must have been one with more than 19–17 scale rows and 7 supralabials.* In the second place, an undoubted form of the *Sirtalis* group occupies almost exactly the same region and probably also the same habitat as *ordinoides*, which opposes the evidence of a closer relationship between *ordinoides* and the *Sirtalis* group.

Its affinity with *elegans*, on the other hand, is shown by the fact that the scutellation and color pattern of *ordinoides* becomes practically identical with *elegans* as the range of the latter is approached, the similarity in the scutellation being brought about by an increase in the number of scales in the dorsal, labial, ventral, and subcaudal series, and by the occasional presence of two preoculars. The resemblance expressed by the similarity in these traits becomes so close in the intermediate region that specimens can not be referred exactly to either form. We believe the conclusion is unavoidable, therefore, that *ordinoides* represents the geographic extreme of the *Elegans* group in North America. If this is true it is interesting to note that it is by far the most dwarfed form among the North American members of the group.

CONCLUSION.

If it be granted from the evidence produced above that *angustirostris*, *melanogaster*, *scalaris*, *phenax*, *hammondi*, *elegans*, and *ordinoides* form a group of genetically related forms (fig. 69), this group is very similar to the *Radix* and *Sauritus* groups above described in that (1) the form with the largest scutellation occurs on the northern part of the Mexican plateau; (2) both to the north and south of this center of maximum scutellation a decrease in the number of scales in each series takes place; (3) in North America the group enters a region that is without effective physical barriers to its northward extension and extends as far to the northward as the increasing

coldness of the climate will permit; (4) the smallest size and scutellation is found in the form that constitutes the distal end of the line of genetically related forms; (5) the intermediate region between the forms is narrow in every case, showing that the change in scutellation takes place rapidly. Again, if the relationships are as I have pointed out, there is a remarkable case of convergent evolution in this group. This is shown by the great similarity in scutellation between *scalaris* and *ordinoides*. If it were not for the peculiar color pattern of the former, it would be impossible without a knowledge of the locality to distinguish specimens of these forms.

FIG. 69. PHYLOGENETIC DEVELOPMENT OF THE ELEGANS GROUP.

THE SIRTALIS GROUP (EQUES, SUMICHRASTI, PARIETALIS, SIRTALIS).

EQUES.[a]

Description.—As in the case of all of the other groups, the maximum scutellation for the *Sirtalis* group (as I have defined it) is exhibited by a species which has its principal distribution on the Mexican plateau. This form is the *Coluber eques* of Reuss, the *Eutaenia cyrtopsis* of Ken-

[a] *Thamnophis eques* (REUSS), Mus. Senckenb., I, 1834, pp. 152–155. Includes *E. cyrtopsis* KENNICOTT, *Thamnophis cyrtopsis cyclides* COPE, *Tropidonotus collaris* JAN, *E. cyrtopsis ocellata* COPE, *E. eques aurata* COPE, *E. pulchrilatus* COPE, *E. dorsalis* BAIRD and GIRARD, and *E. ornata* BAIRD and GIRARD.

nicott and later writers, *Tropidonotus collaris* of Jan, etc. It is a very distinct form and has seldom been confused with others. In every specimen examined the lateral stripe is on the second and third rows of scales, and the dorsal stripe is, as a rule, confined to the median row for the greater part of the length, although it is usually wider on the nape and occasionally occupies more or less of the adjacent rows on the body. The dorsal scale formula is nearly always 19–17, rarely 19–17–15 or 17–19–17. The supralabials are 7 (often), 8 (usually), 9 (frequently), or 10 (rarely); the infralabials are usually 10, occasionally 11, rarely 8 or 9. The oculars may be 1–2, 1–3, 1–4. Ventral scutes 144 (female) to 180 (male). Subcaudals 66 (females) to 97 (males). Proportionate tail length .204 (female) to .292 (male).

The ground color between the stripes is light brown, inclining either to olive or red, and the keels are usually appreciably redder than the rest of the scale. The lateral stripes vary in color from creamy white to light yellow; the dorsal is generally light orange yellow.

The first row of scales is ordinarily light or dark ash, with occasional, paired dark marks at intervals on the upper and lower edges of the scales, the lower mark including the end of the ventrals. In some instances these marks are represented by a single series of spots, each one of which involves the end of a ventral scute and the first and more or less of the second rows of scales, thus encroaching on the lateral stripe and giving it a wavy appearance. There are always two distinct rows of quadrate black spots between the stripes, and these are generally about one and one-half scales wide, and the same distance apart, the interspaces being bluish white. (According to the descriptions of "*dorsalis*" and "*ornata*" specimens the interspaces in Texas and New Mexico specimens may be red.) These spots are on the skin, and are usually represented only on the extreme edges of the involved scales, except anteriorly, where they are represented by a pair of large conspicuous nuchal blotches which cover all of the included scales with the frequent exception of the keels, which often retain their reddish color. The edges of the scales in the interspaces are usually white.

While the arrangement of the spots described above applies to most of the individuals of *eques* that have been examined, it does not include a number of specimens in which the spots show a decided tendency to encroach upon the involved scales forming spots similar to those on the skin (*ocellata* Cope and *collaris* Jan). In such specimens (and these are usually those in which the first row of spots, below the lateral stripe, is better developed) the encroachment of the black pigment upon the scales is generally more pronounced anteriorly. Indeed, it is not uncommon to find individuals with the spots well marked on the scales of the anterior part of the body, but entirely absent posteriorly. Even when distinct on the scales, however, the

black pigment does not always encroach upon the keels, which frequently retain their characteristic rufous tint; but when well developed they often encroach upon the dorsal and lateral stripes, giving them a wavy or interrupted appearance. In a number of specimens which have been examined (mostly from the northern part of the range, see below) the spots in the second and third rows fuse on the anterior part of the body to form distinct cross-bands between the stripes, occasionally also uniting with those of the first row, thus intersecting the lateral stripe. This tendency has not been noted to take place for more than seven spots posterior to the nuchals, which in these specimens are usually fused across the nape and strongly notched posteriorly by the dorsal stripe.

Belly grayish white, light yellow or light greenish yellow. The usual narrow, black bar, and ventral spots may occur alone or together, but in any case rarely show much beyond the edges of the superincumbent scute. The ventral plates are rarely speckled with darker. The head above is usually dark brownish olive splashed with black. The supralabials (with the exception of the last), lower and middle postoculars, and the lower part of the preoculars are usually pale yellow; supralabials well margined with black. The last labial is usually more dusky, approaching the body color. Generally many of the infralabials are also margined with black.

Habits and habitat relations.—Apparently the only observations that have been recorded upon the habitat preference of this snake are those on the three specimens taken in Sabino canyon, Santa Catalina Mountains, Arizona, in 1907 (Ruthven, 1907, 588). "All of the specimens obtained were found near the stream in the canyon. Two were lying on rocks in midstream, the other on the immediate shore. When frightened they immediately took to the water, swimming in the swift current with apparent ease. They doubtless subsist largely upon the frogs and tadpoles which abound in this habitat." Bailey records it in the Davis Mountains, Texas, at an altitude of 5,700 feet.

Range.—*T. eques* is known to range over more degrees of latitude than any other garter-snake that inhabits Mexico, except *proximus*. The range extends from central Guatemala on the south to the high plateau in central Arizona and New Mexico on the north. Specimens have been examined from the following localities: "Central Guatemala," Escuitla, Guatemala; valley of Mexico and Toluca, Mexico; Veracruz, Zacaultipan, Hidalgo; Guanajuato; Rinconado, Puebla; Durango and Coyotes, Durango; Fort Apache, Fort Huachuca, White River Canyon, Sabino Canyon (Santa Catalina Mountains), Fort Whipple, Arizona; San Ildefonso, Lake Valley, New Mexico; Davis Mountains, Pecos, Helotes, San Antonio, Texas.

The literature on this form is rather extensive, but, as far as I can find, no specimens have been recorded outside of the region outlined

by the above localities, except the specimens listed by Boulenger (1893, 209) from Jalisco and Guerrero and the specimen said to have been taken by Xantus at Cape San Lucas, Lower California. I have elsewhere shown (Ruthven, 1907, 588–589) that there is undoubtedly a mistake in the latter record, in that the specimen upon which

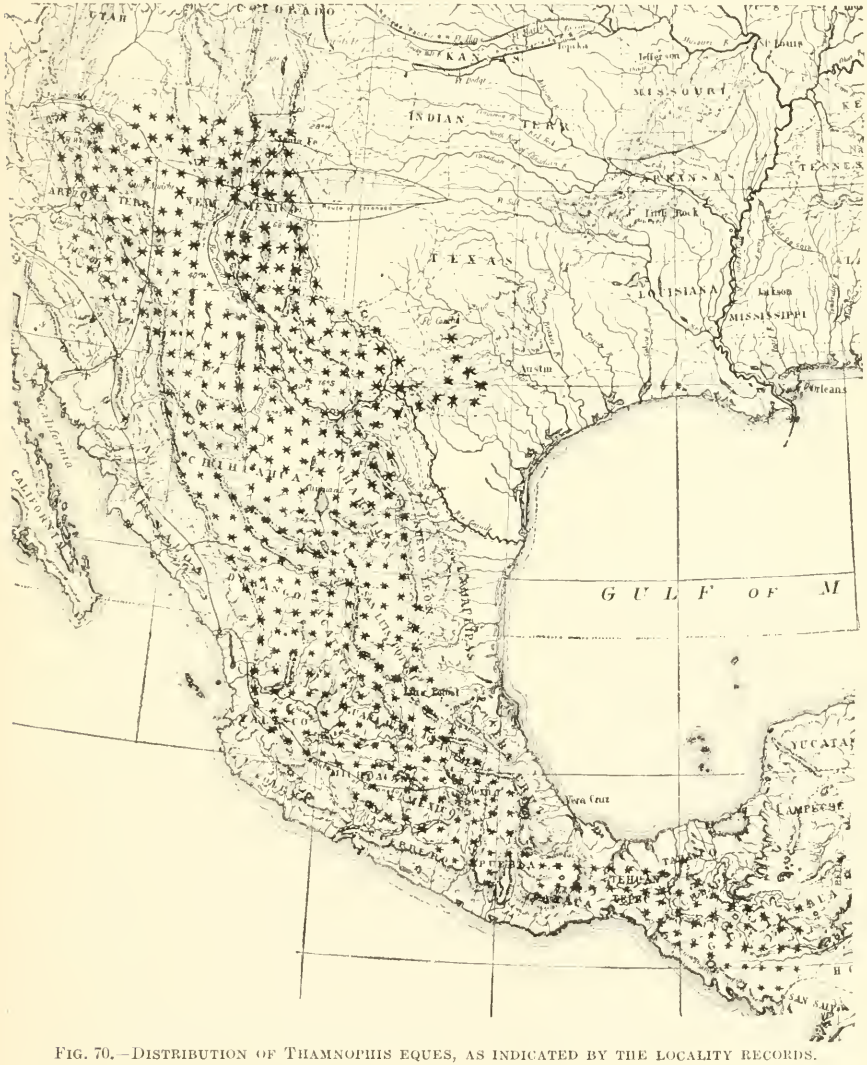


FIG. 70.—DISTRIBUTION OF THAMNOPHIS EQUES, AS INDICATED BY THE LOCALITY RECORDS.

it was based very probably came from Arizona. As known at present, then, the range of *T. eques* may be defined in general as all of Guatemala, Mexico exclusive of the coastal plains, the Proplateau region of southern Arizona and New Mexico, and the high plateau region in the last two named States and western Texas (fig. 70). The

specimens in the U. S. National Museum labeled "Helotes" and "near San Antonio," Texas, seem to indicate that it also occurs in the prairie region of central Texas, but as these localities are near the margin of the high plateau the range of the species can not be extended into the prairie region until notes on its occurrence in this region are at hand. Just how far north it extends is questionable, but the San Ildefonso specimens show that it attains the high plateau region in New Mexico, which might be expected, since it occurs in the mountains in the Proplateau region (Bailey, 1905, p. 48; Ruthven, 1907, 588–589). Similarly its northern limit in Texas also remains to be determined.

Variation.—Naturally in such an invariable form it is difficult to discover geographic differences in any but large series of specimens. Some differences appear in the material examined, however, which seem to be associated with definite parts of the range. In the diagrams (figs. 71 and 72) I have plotted the variations and mean number of dorsal scale rows and supralabials for various localities throughout the range.

It is readily granted that the number of specimens employed in the tables is inadequate to furnish conclusive results in an investigation of the geographic variation in this form, and yet, in view of the narrow limits of variation, I believe that the tables are not deceptive in indicating a slight decrease in the number of dorsal scale rows and supralabial scutes in southern Mexico and Central America. The individual variation is too great in the case of the infralabials, ventral and subcaudal scutes to insure accurate results when the available data is tabulated, but I believe when more material is available that the evidence of these characters will not vitiate the evidence of the dosal scale rows and supralabial plates that there is a reduction in scutellation in the region mentioned. The tendency toward a reduction in the number of dorsal scale rows in the southern part of the range is shown in the occurrence of the formula 19–17–15 and 17–19–17–15 in specimens from this region, which brings the average below 19–17; while similarly the decrease in the number of supralabials in the same general region is shown in the frequent presence of 7, a number which is not shown in any specimens north of the State of Durango. The latter fact justifies me at once in relegating Cope's species *pulchrilatus* (1885 b 174) to the synonomy of *eques*, as this form was based entirely upon specimens of *eques* with 7 supralabials. Cope (1900, 1062) objected to this disposition of the form by Boulenger with the statement that it "belongs to a different section of the genus." He neglects to mention, however, which "section" it is to be referred to, and there is no other evidence besides the number of supralabials that I can find to separate it from *eques*.

The limits of variation in the ventral and subcaudal scutes and tail length have already been given. The averages for the larger

series in which males and females are represented in about equal proportions are about as follows: Ventrals, 160–170; subcaudals, 75–85; tail length, .23; but much larger series are necessary to properly define these characters.

As in the case of scutellation, there is little marked variation in the coloration. However, the specimens in which the dorsal spots

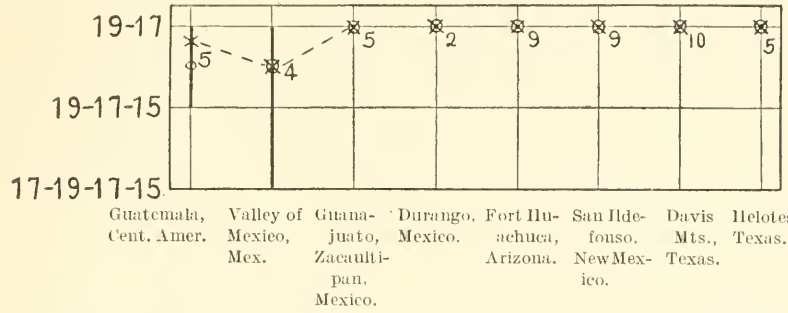


FIG. 71.—DIAGRAM SHOWING THE VARIATION IN THE DORSAL SCALE FORMULA IN THAMNOPHIS EQUES.

tend to become distinct on the scales and fused into cross-bars anteriorly (see p. 159) are principally from the southern part of the United States. Cope (1880, 22–23) has described these as a distinct variety *ocellata* (and Jan has made them the basis of the species *collaris*). This pattern is found in occasional specimens from nearly every

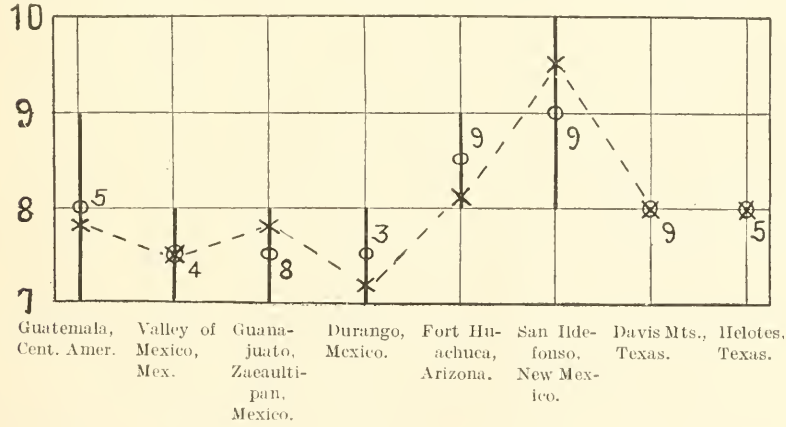


FIG. 72.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF SUPRALABIALS IN THAMNOPHIS EQUES.

locality in the range of *eques*, and while of more frequent occurrence in the northern part still occurs only as an individual variation of the normal coloration. In regard to the loss of the stripes, the case is somewhat different. Thus, in the series in the U. S. National Museum from Zacaultipan, Hidalgo, Mexico, out of six specimens three are typical, *eques*, and the others, while agreeing with them in scutellation, differ in the apparent total absence of lateral and dorsal stripes.

The latter three specimens have been referred by Cope to *sumichrasti*, and conform closely to the original description of that form. Inasmuch, however, as it is impossible to work out the dorsal scale formula of the type (owing to its poor condition) the identity of the Zacaultipan specimens with them can not now be determined. The species was described, however, from specimens from Orizaba, Mexico, and credited with 19 scale rows, which probably means the maximum number, and since specimens from that locality have generally a more reduced number of dorsal scale rows (although the maximum is frequently 19) and a similar coloration, the types of *sumichrasti* are undoubtedly identical with such specimens which are to be referred to a different form. I believe the specimens from Zacaultipan, without stripes, can be considered only as variations of *eques*, which possibly indicate that the form tends to lose the stripes in this region.[a]

Affinities.—If I have proven that there is a tendency toward a reduction in the dorsal scale formula below 19–17, and toward the obscuring of the stripes, the only objection to the conclusion that *eques* is very closely related to the following form (*sumichrasti*) has been eliminated. As will be shown in the description of the latter, there are no appreciable differences between so-called *sumichrasti* specimens from Orizaba, Veracruz, and typical *eques* except in the slightly larger number of scale rows of the latter; a discrepancy that entirely disappears when it is noticed that in the intermediate region, geographically, the scutellation of *eques* tends to become apparently exactly that of *sumichrasti*. On the north we believe that it is directly related to *parietalis* (see p. 172).

SUMICHRASTI.[b]

Description.—I use this name to designate those specimens, so far recorded only from southern Mexico, that otherwise combine the usual coloration of *eques* with a reduced scutellation and the usual absence of the dorsal stripe.

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[a] I can find absolutely no character in which the types and only specimens of *Eutaenia aurata* Cope (1892, 659–660) and *Thamnophis cyrtopsis cyclides* Cope (1862, 299) differ from typical *eques* specimens.

[b] *Thamnophis eques sumichrasti* (Cope), Proc. Acad. Nat. Sci. Phila., 1866, p. 306. Includes also *E. chrysocephala* Cope and *Tropidonotus godmani* Günther. I use this name advisedly. As before stated, the types of *sumichrasti* are in very bad condition, but they are apparently very similar in coloration to so-called *chrysocephala* specimens from the same region. Cope always distinguished the former as having 19 scale rows and the latter as having 17, but since typical *chrysocephala* specimens with 17–19–17 scale rows are found in Veracruz, the distinction is not a sufficient one. Since also both forms are characterized by the usual obscurity of the dorsal stripe, I feel justified in concluding that it was upon specimens of this kind that Cope based his description of *sumichrasti*, which name should, therefore, be the name of the form. *Tropidonotus godmani* was evidently based on a specimen of this form with a dorsal stripe.

The writer has seen but eleven specimens of this form (inclusive of the damaged types of *sumichrasti*), but these are so uniformly unique that he has no hesitancy in giving them the rank of a form The lateral stripes are generally present, although occasionally not very distinct, and are in every specimen on the second and third scale rows anteriorly, but generally only on the second posteriorly. The dorsal stripe is usually absent, although occasionally present for a short distance anteriorly, more rarely for the entire length. Coloration otherwise much as in *eques*, the ground color being brownish with lighter keels, and the lateral spots little evidenced upon the scales, except anteriorly, where they form a pair of distinct nuchals and occasionally one or two large transverse blotches between the stripes. The scutellation has been summarized in the following table:

Scutellation of Thamnophis sumichrasti Cope.

No. U.S. N. M.	Locality.	Dorsals.	Supralabials.	Infralabials.	Oculars.	Ventrals.	Subcaudals.	Total length.	Tail length.	Proportionate tail length.	Remarks.
								mm	*mm*		
26501	Orizaba, Mexico	(?)	8	9	1-3	(?)	(?)	(?)	(?)	(?)	Type.
26502	.....do.....	(?)	8	(?)	1-3	(?)	(?)	(	(?)	(?)	
7077	.....do.....	17-15	8	9	1-3	147	(?)	(?)	(?)	(?)	
7077a	.....do.....	17-15	8	10	1-3	149	(?)	(?)	(?)	(?)	
7077b	.....do.....	17-15	8	10	1-3	155	(?)	(?)	(?)	(?)	
7077c	.....do.....	17-15	8	8 10	1-3	149	76	496	126	0.254	
7077d	.....do.....	17-15	8	9 10	1-3	147	74	425	108	.242	
7077e	.....do.....	17-15	8	10	1-3	152	83	223	55	.246	
7077f	.....do.....	19-17-15	8	10	1-3	155	(?)	(?)	(?)	(?)	
30494	.....do.....	17-15	8	9 10	1-3	153	80	530	136	.256	Type of *chrysocephala*.
30496	.....do.....	17-19-17-15	8	10	1-2 1-4	154	(?)	(?)	(?)	(?)	

As shown from this table, the form *sumichrasti* as now known is characterized by a small dorsal scale formula, and exhibits an apparent tendency toward a smaller number of infralabials than 10, and possibly also a smaller number of ventral plates than is usual in the larger members of the genus. The tail length as far as shown by the material is similar to that of most of the forms exclusive of those of the *Sauritus* group.

Range.—The only specimens of *sumichrasti* that I have seen are from Orizaba, Veracruz. Boulenger (1893, 203) records specimens of *chrysocephalus* from Omilteme and Amula, Güerrero, Günther (1894, 133) specimens of *godmani* from the same localities, Bocourt a specimen of *sumichrasti* from Coban, Guatemala, and Cope a specimen of *sumichrasti* as possibly from "the Plateau of Costa

Rica at Cartago." Needless to say the dorsal scale formula of these specimens should be carefully examined to make sure that they are are not *eques* specimens with obscure stripes. As already stated, it seems advisable to refer to *eques* the specimens from Zacaultipan, Hidalgo, determined as *sumichrasti* by Cope.

Affinities.—As already mentioned under the discussion of *eques*, I believe that these two forms are directly related. They are remarkably similar except for the smaller dorsal scale formula and usual obscurity of the dorsal stripe in *sumichrasti*, and since I believe it demonstrated that there is a tendency toward a reduction in the number of dorsal scale rows and an obscuring of the stripes in *eques* in southern Mexico, there can be no objection to considering the individuals from Orizaba, Mexico, as representing the continuation of this process. The form apparently lies entirely without the province of *eques*, and intergrades with the latter through such specimens as the ones from Hidalgo, valley of Mexico, etc., referred by Cope to *sumichrasti* and *pulchrilatus*. Just where the intergradation occurs can not now be determined, but it should be noted that the difference in the number of scale rows must be brought about in quite a narrow area, since the formula 19–17 is quite constant in *eques*, even in the States of Hidalgo and Mexico, where it comes close to the range of *sumichrasti*.

PARIETALIS.[a]

Description.—This form is so well defined that it has seldom been confused with any other, and has avoided the fate of so many other forms, i. e., being broken up into a number of subspecies. The dorsal scale formula is always 19–17; the supralabials usually 7, frequently 8, but very rarely 6; the infralabials usually 10, occasionally 9, more rarely 11, and very rarely 8; the ventral scutes 150 to 178; subcaudals 65 to 92; tail length .202 to .32.

The general coloration is as follows: Ground color above dark olive to brownish olive or dull reddish brown, the color being confined to the scales between, and the keels of the scales involved in, the lateral spots. The latter are arranged in two rows on the skin between the lateral and dorsal stripes; occasionally the spots in both rows distinct, but those of the upper row usually fused for more or less of their width to form a black band, the spots of the lower row appearing as downward projections from this band. The black pigment of the spots only encroaches upon the edges of the involved scales. The interspaces on the skin vary from orange to red, and this pigment nearly always encroaches on the edges of the involved scales. The first few

[a] *Thamnophis sirtalis parietalis* (Say), Long's Exped. Rocky Mts., I, 1823, p. 186. Includes *Eutænia sirtalis trilineata* Cope (part), *E. sirtalis tetratænia* Cope (part) (see also p. 176), and *E. sirtalis dorsalis* Cope (not *E. dorsalis* Baird and Girard; see p. 158).

spots anteriorly of the two series may fuse to form transverse blotches between the stripes. The dorsal stripe is on the median and halves of the adjacent rows and with the lateral stripes may be bright orange yellow, bright yellow, various shades of greenish yellow, or bluish. The first row is usually sufficiently darker to define the lateral stripe below, but this is not always the case. The belly may be grayish, greenish, or bluish. The better marked variations from the normal type will be considered under "variation."

Habits and habitat relations.—Few definite observations have been recorded on the habits of this form. Stomachs examined frequently show specimens of the leopard frog (*Rana pipiens*), and Taylor (1892, 325) writes that in Nebraska "specimens of this garter, not exceeding two and one-half feet in length almost always contain within their stomachs specimens of the common earthworm." Specimens in captivity will eat both frogs and toads voraciously.

In northern Iowa *parietalis* is rather rare. On a two months' collecting trip in Clay and Palo Alto counties, July and August, 1907, an expedition from the University of Michigan Museum obtained but three specimens, although a careful search was made for them. Of these two were found on the immediate edge of large sloughs (fig. 23), the third in a rather swampy swale on the prairie. We have also, however, taken a few specimens in the long grass on the uplands in this region (fig. 24), but they are apparently very rare in this habitat. Another specimen was taken on the bank of a small creek near the Missouri River, in Woodbury County, Iowa. One of the specimens taken in Palo Alto County in 1907 was a large female, and on September 30 gave birth to seventy-three young.

Range.—It is rather interesting that, although *parietalis* has been well known for many years, the limits of its range can nowhere be established at present except on the west. Its range is greater than that of any other known garter-snake and includes a number of biotic regions. It may be said in general to extend from the western part of the "prairie peninsula" in Iowa to the Cascade range in Oregon, Washington, and British Columbia and to the Pacific coast in California, and from northern New Mexico into Canada. Undoubted specimens have been examined from the following localities: Menlo Park, Fort Reading, Pitt River, San Francisco, Petunia, Fort Crook, Fresno, Crescent City, Tomales Bay, Petaluma, Eureka, Yosemite Valley (altitude 4,000 feet), Palo Alto, Camp Bidwell, California; Gold Beach, Des Chutes River, Dalles, Warners Second Lake, Oregon; Cheney, Pullman, Fort Walla Walla, Washington; Sicamous, Nelson, Kaslo, Donald, British Columbia; Lake Tahoe, Camp 10 and 12 (Ridgway), Nevada; Carson Valley, Logan (10 miles east of), Utah; Fort Collins, Denver, Greeley, Colorado; Flathead Lake, Swan Lake, Fort Benton, Bitter Root Mountains, Billings, Fort Custer, Three

Forks, Fish Creek, Montana; Peabody, Onaga, Fort Riley, Fort Harker, Kansas; Platte River, Fort Kearney, Nebraska; Ames, Des Moines, Palo Alto County, Clay County, Woodbury County, Iowa.

Further collecting will extend the range somewhat beyond the extreme points listed above, to the north, south, and east. At present the most debatable territory is to the south and east, for here *parietalis* meets two allied forms (*eques* and *sirtalis*), which it resembles so closely that it is impossible to distinguish preserved specimens with certainty. This is true of specimens from northern New Mexico and Arizona, and Minnesota, eastern Iowa, and western Illinois. The points of resemblance between these forms will be discussed under "variation," but it should be stated here that no reliance can be placed upon the published lists which record *parietalis* for any of the last named States. Thus, Cope records it from Lake Valley, New Mexico, but the basis of the record proves on examination to be a specimen of *eques*, while apparently several of his *dorsalis* specimens from the same state, as well as Garman's Illinois specimens and Ruthven's Isle Royale specimens (1906, 111–112), are not at all typical and are mostly to be considered "intermediate." At the present time the eastern limit of typical *parietalis* may be given very generally as the "prairie peninsula" in central and southeastern Minnesota, eastern Iowa, and northeastern Missouri. The southern limit in central United States can not even be approximated, although it doubtless lies in the northern part of Texas, Arizona, and New Mexico. The southernmost point from which we have examined specimens from California is Fresno, but Van Denburgh (1897, 203) records it from "San Bernardino (Ontario) and Riverside (Riverside) counties," and Grinnell (1907, 49) from the Pacific slope of Los Angeles County. The known range has been platted on the map (fig. 73).

Variation.—Like its relatives, *eques* and *sirtalis*, *parietalis* is little variable in scutellation. Large series alone, therefore, will reveal geographic differences if they exist. Unfortunately, while I have examined about three hundred and fifty specimens, these have been from many localities, so that single regions are represented only by small numbers. On the other hand, in view of the constancy of the characters, geographic variations must be very slight, and I believe that the data accumulated is quite representative of the actual conditions. In every specimen in which they were counted (311) the dorsal scale formula is 19–17. In regard to the labials, the suites are all alike in that most of the specimens have the labial formula 7/10, but quite frequently 8 supralabials and 9 or 11 infralabials. I have seen but four specimens in which the variation exceeded this amount, one from Eureka, California (Field Museum, 1111), and three from Pullman, Washington (Ruthven collection), each of which

have 8 infralabials on one side, and one from Pullman, Washington (Ruthven collection, No. 11), which has 6 supralabials on one side.[a]

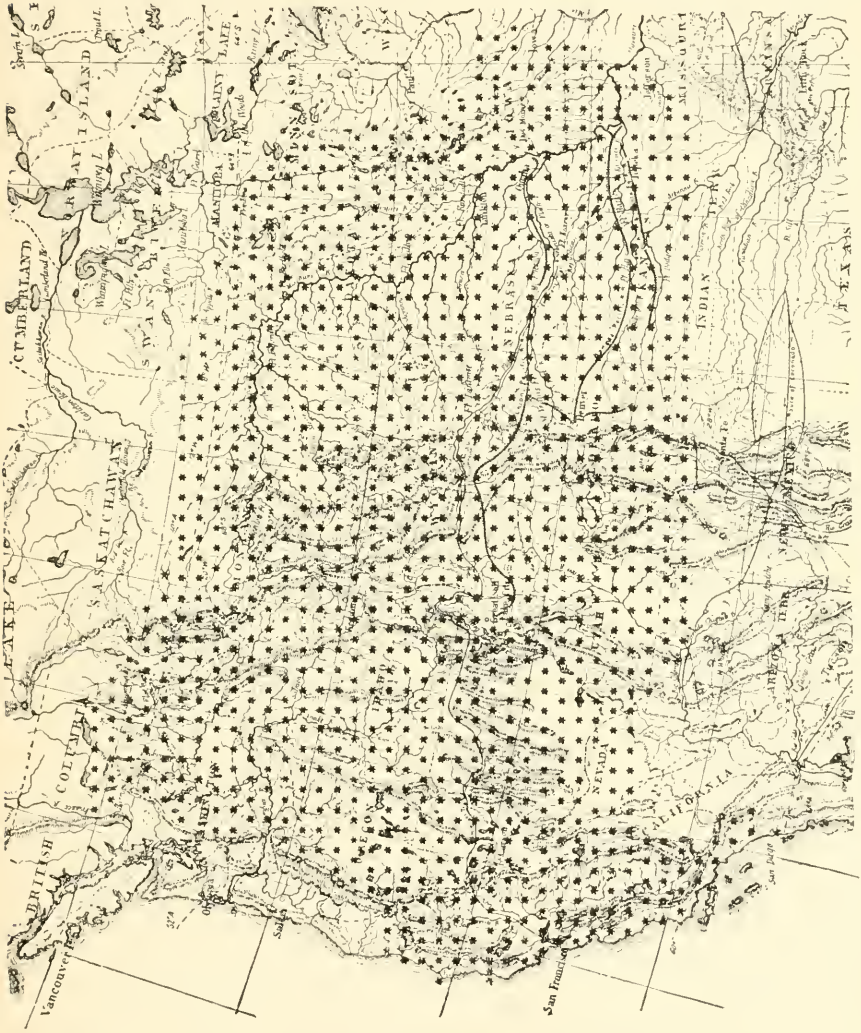

FIG. 73.—DISTRIBUTION OF THAMNOPHIS SIRTALIS PARIETALIS, AS INDICATED BY THE LOCALITY RECORDS.

The extent of the variation in the labial formula may be seen in the diagram (figs. 74–75), for the Montana specimens. The conditions

[a] It is worth recording here that a female from Pullman, Washington, which the writer kept in captivity, and which had a labial formula 7/10, gave birth to eleven young none of which had more than 9, while three had 8 infralabials on one side, and none had more than 7, and one had 6–7 supralabials. There is, in regard to the labials, more reduced specimens in this brood than in the series from any other locality. The difference is not geographic, as six specimens from Walla Walla have 7/10, with one exception, in which there are 9 infralabials on one side. All that can be said is that the cause that brought about the reduction apparently affected the entire brood.

represented in these diagrams are typical for every locality examined, as far as can be judged from the material at hand.

The ventral scutes vary as follows: Females, 150–165; males, 153–178. The average for thirteen specimens from California (west of the Sierra Nevadas) is 161, for twenty Montana specimens, 163.7. The subcaudal plates vary as follows: Females, 65–80; males, 73–92; average number for twelve specimens from California, 82; for thirteen specimens from Montana, 81.3. The material at hand is not sufficient to throw much light upon the proportionate length of tail. The extremes are .202–.262 (female), .239–.32 (males). The average for different localities with more than twelve specimens falls between .23

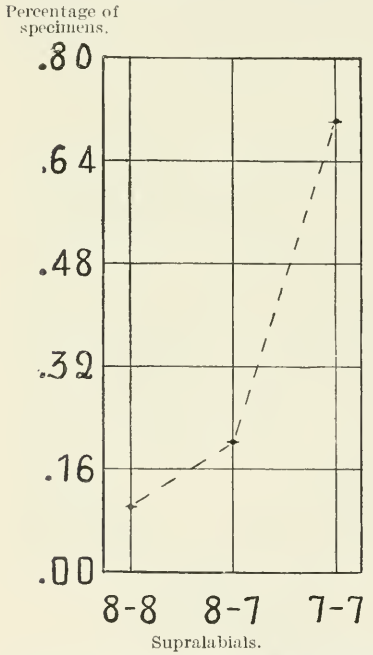

FIG. 74.—VARIATION IN THE NUMBER OF SUPRALABIALS IN 20 SPECIMENS OF THAMNOPHIS SIRTALIS PARIETALIS FROM MONTANA.

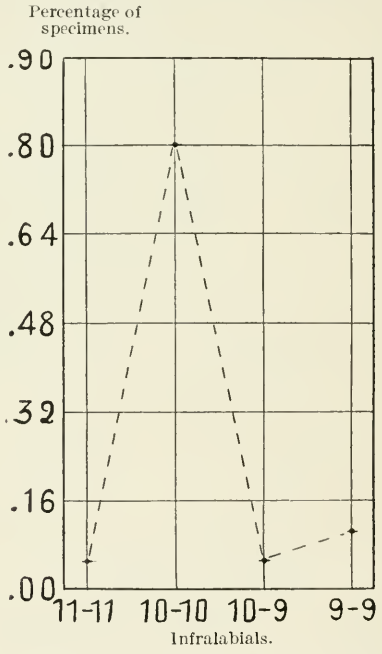

FIG. 75.—VARIATION IN THE NUMBER OF INFRALABIALS IN 20 SPECIMENS OF THAMNOPHIS SIRTALIS PARIETALIS FROM MONTANA.

and .25, but to what extent these averages are constant throughout the range is a question which awaits investigation.

The more striking variations in color in *parietalis* are principally in the way of modifications in the arrangement of spots, the intensity of the ground color, and the color of the interspaces on the skin. It should be recalled that the usual coloration is: Ground color, olive or reddish brown; upper row of spots fused on skin; interspaces about one scale wide and red in color; dorsal stripe on the median and halves of adjacent rows. The variations are as follows:

(1) Ground color above, black; interspaces, narrow (from three-fourths to one-half the width of a scale); dorsal stripe on the median

and halves of the adjacent rows. Such specimens are characterized only by the slight excess of black pigment. We have seen this color phase only in specimens from western Montana (Fort Benton, Flathead Lake, Three Forks, Bitter Root Valley) and the west slope of the Rocky Mountains in southern British Columbia. It was principally on *parietalis* specimens of this type that *E. sirtalis trilineata* Cope (1892, 665) was based, but the characters are not sufficient to warrant the separation of these specimens from *parietalis*. They are indistinguishable from some specimens of *concinnus* (see p. 176).

(2) Quite often in typical *parietalis* specimens the red pigment of the interspaces shows a tendency to encroach upon the black areas, particularly between the fifth, sixth, and seventh scale rows, to the partial or total separation of the lower row of spots from the upper black band. This is not at all remarkable, since it is these scale rows which mark the limits of the spots in garter-snakes which have the two rows distinct. In two specimens from Pitt River, California (Cat. Nos. 21383 and 21384, U.S.N.M.), the separation of the two rows of spots is complete, and a further modification exists in the fact that the lower row of spots, like the upper, has also fused into a longitudinal black band. These specimens have been described as *E. sirtalis tetrataenia* Cope (Yarrow, 1875, 546), but they are, in my judgment, evidently only two anomalous specimens of *parietalis*, and this conclusion is supported by the fact that in one of these specimens (No. 21383) the lower black stripe is partially broken up into spots. A similar pattern is occasionally exhibited by *concinnus* (see p. 176).

(3) A number of specimens of *parietalis* from Kansas and Minnesota examined have the first few spots anteriorly fused into transverse blotches between the stripes, as in some Illinois specimens of *sirtalis* described by Cope as *Eutaenia sirtalis semifasciata*, and in the *eques* specimens described by him under the name *ocellata*. This is merely an individual variation, but may have some significance (see p. 173).

(4) By far the most significant variation exhibited by *parietalis* is the breaking up of the lateral black band into the usual upper row of spots. If this alone takes place the result is a coloration practically the same as that of *eques* and *sirtalis*, except that the interspaces are red. We have seen this color phase in Colorado (Greeley) and eastern Kansas (Onaga) and Isle Royale, Michigan, specimens, but it can only be certainly determined in fresh material, for the red of the interspaces fades rapidly in preserved specimens, so that they can not with certainty be distinguished from *eques* (when there are 8 supralabials) and *sirtalis*, the more so that the modification seems to occur only near the ranges of these forms.

In Minnesota, eastern Iowa, and Missouri the proportion of specimens with two distinct rows of spots is large, and the specimens from this region are further characterized by the frequent absence of red pigment on the sides, a character which is also occasionally found in

Kansas and Nebraska specimens. Just what influences the presence of this red pigment can not now be determined, but it is interesting to note that in a series of sixty-five young born in captivity of a typical *parietalis* mother (upper row of spots fused and red interspaces) from Clay County, Iowa, but one showed the least trace of red at birth, and this one but little, showing that the red color may be developed to a large extent after birth, as in most North American birds. Eastern specimens with two rows of spots and red interspaces have been examined from eastern Kansas, eastern Iowa, eastern Missouri, and Isle Royale, Lake Superior. The Colorado and New Mexico material in which specimens with the same arrangement of spots occur were referred by Cope to *dorsalis*.

Affinities.—One need not search far for the relatives of this form. There can be no question but that to the eastward it grades into *sirtalis*, and although, as before stated, typical specimens of *parietalis* may be found as far east as eastern Iowa and *sirtalis* specimens as far west as Kansas, the section of this form which inhabits the entire prairie region (i. e., east of central Kansas and Nebraska) as well as the edge of the adjoining forest region [a] may be considered as intermediate, for in this region the distinctive characters which separate typical *parietalis* (upper row of spots fused and red interspaces) break down.

The presence of specimens in Colorado with two distinct rows of spots is also significant, inasmuch as such individuals are indistinguishable from *eques*, when the red of the sides has disappeared, for we have already noted that *eques* may have 7 supralabials, and apparently shows a tendency to have red interspaces in Texas and New Mexico. This is why it is impossible to define at present the respective southern and northern limits of the two forms, points which can not be settled until their relations are worked out from fresh material. Since, however, in the two forms the scutellation (with the exception of the number of supralabials), proportions, and position of the lateral stripes are approximately the same, while the ranges are at least near together, the evidence seems to indicate a close relationship, and we believe that the similarity in coloration of specimens from near the common boundary is such as to indicate an actual intergrading. As already noted, the number of infralabials is noncommittal in small series, as they may be 7 or 8 in both forms.

Specimens have been examined from as far south as Taos, San Ildefonso, Las Cruces, and Albuquerque, New Mexico, that can be referred to *parietalis*, as well as others from San Ildefonso that are apparently *eques*, but this does not signify that intergradation does not occur. The whole question must await further investigation,

[a] I have elsewhere noted that on Isle Royale, Michigan, which is well within the forest region, most of the individuals are typical *sirtalis* in coloration, but that specimens are also found in which the lateral spots are in two rows and the interspaces bright red.

when fresh specimens shall be available from this region. At present we can only say that the forms are undoubtedly closely related, and belong to the same group.[a] In the northwest *parietalis* meets another form (*concinnus*), with which it is closely allied. The relationship of these forms will next be discussed.

CONCINNUS.[b]

Description.—Doctor Hallowell (1852, 183), in his description of this form, concludes with the remark that it is "The most beautiful of the North American serpents hitherto discovered." His enthusiasm is easily realized by anyone who has the good fortune to see living specimens. The form differs from *parietalis* only in the increased amount of black pigment and the attendant effect upon the pattern. The dorsal scales, including the first row, are generally black, with the exception of more or less of the scales involved in the interspaces, which are red. The stripes may be brightly colored, but are usually yellowish, greenish, or bluish. The lateral when present is on the second and third scale rows, but is frequently absent; the dorsal is generally confined to the median row, but may also cover the halves of adjacent rows or be entirely obsolete. The spots when distinct are arranged as in *parietalis*, i. e., those of the upper row fused, those of the first row distinct from each other but fused with the upper row. The interspaces (always red) are, when present, however, generally much narrower (being only one-half to one-fourth a scale wide) than in *parietalis* and are frequently entirely absent, the skin being solid black. Belly usually dark greenish or bluish, and generally much speckled with black and occasionally orange.

It will be seen from the above description that there is no character which will constantly distinguish specimens of *concinnus* from *parietalis*. The narrow dorsal stripe and lateral interspaces of the former will usually do so, but these may be exactly as in *parietalis*. Still, the fact that nearly all specimens from Washington and northern Oregon, west of the Cascade range, are characterized by a marked predominance of black pigment and a narrow dorsal stripe justifies their recognition as a separate form.

Habits and habitat relations.—As far as I know very little has been recorded on the habits of this snake. Cooper and Suckley (1860, 297) record the following notes:

> This species exists in great abundance near Steilacoon and Nisqually. They are found on the gravelly prairies and in the vicinity of the numerous small lakes of this section of country. About the first of April they begin to come out of winter

[a] It is interesting to note that the three forms, *eques*, *parietalis*, and *sirtalis*, all exhibit the occasional tendency toward the fusion of the first few anterior spots into cross-bars.

[b] *Thamnophis sirtalis concinnus* (Hallowell), Proc. Acad. Nat. Sci. Phila., 1852, pp. 182–183. Includes *Eutænia pickeringi* Baird and Girard, *E. sirtalis trilineata* Cope (part), *E. sirtalis tetrataenia* Cope (part).

quarters, and can be seen at midday sunning themselves near small clumps of scrub-oak bushes, to which they retreat when alarmed. A little later they are found in couples or in small companies. Although they are rarely ever found more than one-eighth of a mile from water, they are, nevertheless, still more anxious to be close to it as the season advances. They will then (in May and June) be found lying close to the water, on the lake shores in the grass, and among the sedge of the marshes, and even upon small bog islands, as much as 50 yards from the shore.

In summer, like other members of this genus, they are found lying in small pools and in the water at the edges of the lakes during the heat of the day. They appear to be a harmless, lazy species, and, as above stated, exceedingly fond of the water.

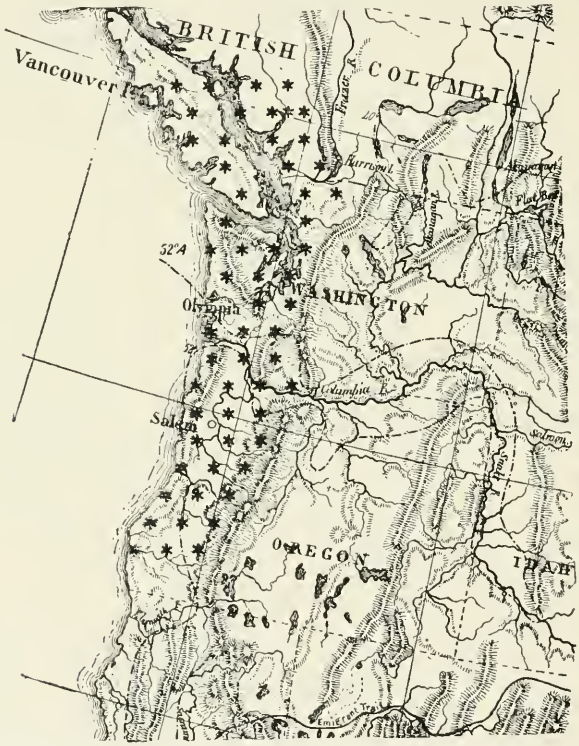

FIG. 76.—DISTRIBUTION OF THAMNOPHIS SIRTALIS CONCINNUS, AS INDICATED BY THE LOCALITY RECORDS.

Range.—The range of *concinnus* is apparently rather definitely bounded on the east and west, since it ranges from the Pacific Ocean to the Cascade range. Specimens which I have referred to *concinnus* have been examined from the following localities: Portland, Eugene City, Oregon; Shoalwater Bay, Fort Vancouver, Tacoma, Puget Sound, Seattle, Fort Steilacoon, Olympic Mountains, Port Angelus (30 miles from), Lake Washington, Washington; Comox Lake, Victoria, British Columbia (fig. 76).

Variation.—Judging from the available material, *concinnus* is identical with *parietalis* in scutellation and proportionate tail length.

The variations and averages in these characters for nearly all of the specimens examined are placed in the following table:

Locality.	Dorsals.	S. labials.		I. labials.		Ventrals.		Subcaudals.		Tail length.	
		Range.	Ave.	Range.	Ave.	Range.	Ave.	Range.	Ave.	Range.	Ave.
(*24 specimens.*)											
Fort Steilacoon, Seattle, Tacoma, Puget Sound, Washington	19–17	7–8	7.1	8–10	9.8	152–170	163	63–90	76.5	0.215–0.286	0.252
(*3 specimens.*)											
Port Angelus, Olympic Mountains, Washington	19–17	7–8	7.7	9–10	9.7	155–165	162	79	79	.20–.259	.238
(*7 specimens.*)											
Comox, Victoria, Vancouver Island	19–17	7–8	7.1	8–10	9.4	160–170	164	69–86	76	.219–.266	.238
(*9 specimens.*)											
Portland, Oregon	19–17	7–8	7.1	9–10	9.8	152–172	164	68–86	77.2	.208–.265	.242

The variation in color has been briefly treated in the general description. There are two color phases, however, that are quite well marked.

(1) Stripes usually present, the dorsal generally confined to the median row. Spots of first row either distinct or not differentiated. Belly blackish. This is the type of color described by Baird and Girard and since known as *pickeringi*. It is found in western Washington and to the northward.

(2) Ground color black. Lateral stripe absent. Interspaces (red) present. Dorsal stripe occupies the median and adjacent half rows. Belly blackish. This is *Tropidonotus concinnus* Hallowell. So far the only specimens that we have seen hail from Portland and Eugene City, Oregon, and it is interesting to note that out of nine specimens from this immediate region (in the U. S. National Museum) every one is of this type. Notwithstanding the fact that it has thus apparently a different range from color phase (1), I am in harmony neither with those herpetologists who consider this color phase as an individual variation of *paricta lis* nor with those who would give it subspecific rank. To me it seems that its distinctive traits (width of dorsal stripe, together with a loss of the lateral) are too slight for the latter position, and that the increased amount of black pigment classes it distinctly with the melanistic form that inhabits western Washington

and the adjoining part of British Columbia; in which case the name *concinnus* Hallowell (1852) takes precedence over *pickeringi* Baird and Girard (1853).

As stated under *parietalis,* variations in color occur which are indistinguishable from some of those of that form. Thus, the black pigment on the sides may be disposed as two black bands separated by a red one, and it was upon a specimen of this kind from Puget Sound, Washington, as well as the two from Pitt River, California (p. 171), that Cope based his subspecies *tetrataenia.* Similarly, when the dorsal stripe occupies one and two half rows, as it occasionally does, the specimens are very similar to dark specimens of *parietalis* from Montana, and in fact one of the type specimens of *trilineata* was a *concinnus* from Fort Townsend, Washington.

Affinities.—Concinnus grades directly into *parietalis* through dark specimens of the latter (the phase *trilineata*) in the Cascade range. It has no direct relationship with *ordinoides,* as may be seen by the scutellation, for we have shown that *ordinoides,* has generally less than 19–17 scale rows, while the variations above this number in the latter indicate that it is derived from a form with a larger formula than 19–17.

SIRTALIS.[a]

Description.—This form is one of the best known in the genus, probably owing largely to the fact that it is very common in a thickly settled region. At the present time the material available for study numbers nearly as many specimens as that of all the other forms combined.

The lateral stripe is always on the second and third scale rows, and the eye is large. The dorsal stripe usually occupies the median and halves of the adjacent rows, is frequently narrower and occasionally wanting. The dorsal scale formula is practically always (in 598 out of 600 specimens examined; see p. 181) 19–17; the supralabials nearly always 7, occasionally 8, rarely 6; the infralabials 10, occasionally 9 or 11. The oculars are usually 1–3, often 1–4, more rarely 1–2; the subcaudals 54 (female) to 84 (male); the ventrals 137 (female) to 167 (male). Tail length .192 to .262.

The ground color above varies from light green, light greenish olive, or light olive brown to dark greenish olive, dark olive brown, brown, or black. The first row of scales is generally (but not always) much lighter than above, but still somewhat darker than the second and third rows. There are two rows of well-defined spots (rarely fused) on the skin between the lateral and dorsal stripes, and these usually cover more or less of the involved scales (exclusive of the

[a] *Thamnophis sirtalis* (Linnaeus), Syst. Nat., 10th ed., I, p. 222. Includes *Coluber ordinatus* Linnaeus, *Eutaenia sirtalis graminea* Cope, *E. sirtalis obscura* Cope, *E. sirtalis semifasciata* Cope, and *E. sirtalis pallidula* Allen.

keels). The spots are not usually distinct upon the scales, however, owing to the darkness of the ground color. Interspaces on the skin white or bluish white, never red except occasionally immediately along the lateral stripe. Stripes greenish or bluish, usually tinged with yellow. Ventral surface greenish or bluish slate. Ventral spots usually well defined. Sides of head greenish, yellowish, or bluish; labials partly margined with black.

Habits and habitat relations.—Even in the case of this well-known form but little has been recorded on the habitat relations. The expe-

FIG. 77.—FORESTS IN THE PORCUPINE MOUNTAINS, MICHIGAN. THAMNOPHIS SIRTALIS IS OF GENERAL DISTRIBUTION IN SUCH FORESTED REGIONS IN EASTERN UNITED STATES.

rience of the writer indicates that it is quite generally distributed in the Eastern forest region, for while it is found most commonly in the vicinity of water, it is not uncommon in the clearings, woods, and thickets on the neighboring hills (fig. 77).

The food consists principally of frogs, toads, salamanders, earthworms, and various insects. Whether or not it feeds to any great extent upon tadpoles and fish is undetermined. Garman (1892, 268) states that they eat these animals, and I have observed them to

capture fish in captivity, but since in the wild state they are not particularly aquatic, the truth of the matter is probably that they capture these forms when they encounter them in small pools, but that this is comparatively seldom. The number and kinds of insects eaten is also a questionable point. It is true that many species are found in the stomachs examined, but, as Surface (1906, 149) says, many of these are "taken inside of the toads and other batrachians which the garter-snake had eaten." However, both adults and young are very fond of earthworms. As other garter-snakes, *sirtalis* apparently does not refuse dead food. Mr. N. A. Wood, of the University of Michigan, reported to the writer, on May 18, 1907, that he saw a specimen of this species swallowing a yellow warbler, which he had observed lying dead in the same place on the preceding day. In the latter part of October, 1907, the writer discovered an individual at Portage Lake, Washtenaw County, Michigan, busily engaged in an attempt to swallow the dried remains of a large green frog (*Rana clamitans*).

The breeding habits have been commented upon several times, but are as yet only incompletely known. In southern Michigan copulation takes place in April, and at this time it is reported on good authority that these snakes often collect in groups, probably owing to the procreative impulse. I have not witnessed this nor can I find any observations on the act of copulation. The latter I have seen but once, and then but imperfectly. It took place on April 21, 1906, between two specimens in captivity. The male in this case lay at full length beside the female, and evidently attempted to excite her by gently rubbing her neck with his snout. He finally threw a fold of his tail across hers, and turning his ventral surface against her side began spasmodic contractions of the abdominal muscles, which were continued from twenty to thirty minutes. Unfortunately the snakes were then disturbed and the observations ceased. They indicate, however, that there may be some interesting courtship reactions to be observed in these snakes.

The period of parturition extends from the latter part of July to about the middle of September. Both of these dates are only approximate, as definite observations are wanting. The number of young is very variable, the average range in number being probably about 10–30, while as many as 78 have been recorded in a single brood, which is not at all an unusual number, since *parietalis* may have, according to our observations, as many as 73. After birth the young remain for a short time about the mother, but this time is probably limited to a few hours at most. In captivity there is little tendency discernable to stay near the mother, and although we have several times seen a mother and her brood in a wild state, in every case noted, when the mother became alarmed, or for some other reason moved away, the young scattered in all directions, and it is improbable that they ever

came together again. The quickness and completeness with which the little snakes disappear when alarmed may partly explain the fable that this snake swallows its young.

Ditmars (1907, 235–236) gives the following interesting account of the hibernating habits:

> The favorite situations in which to pass the cold months are in soft soil on a slope that faces the south. Here the reptiles burrow down a yard or more. Rocky situations are often selected, and among the clefts and fissures, one opening into another, the snakes are enabled to retire to a considerable depth from the surface.
>
> It is in the fall that these snakes congregate in large numbers on ground that is suitable for the winter's sleep. Here they sun themselves during the middle of the day, retiring into clefts and burrows during chilly autumn nights. As the nights become colder, their basking periods during the day are shortened, and finally, after the first severe frost, they remain below the ground for the winter. Instinct seemingly attracts them to these places of hibernation, for such spots are usually poor feeding grounds and have been devoid of snakes during the summer months. In spring, the breeding time, the reptiles remain in numbers until the weather has become well settled and the danger of needing good shelter from the cold spells has passed. Then they scatter into the ravines, the thickets, along streams and brooks, until the scene that has abounded with sinuous, crawling life is deserted.

This account harmonizes very well with the writer's observations in southern Michigan. In the latter region they are found in the autumn on sunny hillsides in the immediate neighborhood of holes, into which they hasten when alarmed, but that they dig these holes themselves yet remains to be proven, nor after the beginning of the period of hibernation do they necessarily "remain below the ground for the winter," for if periods of marked moderation in the temperature occur they will come out in December, January, or February. Thus, on January 22, 1906, which was a warm day (60° F.) in a period of very moderate temperature, a collector for the University of Michigan Museum reported seeing a large garter-snake near Grass Lake, Washtenaw County, Michigan, which was undoubtedly this species.

Range.—This form is practically confined to the eastern wooded district of North America. Thus, its range on all four sides is rather definitely bounded—on the south by the Gulf, on the east by the Atlantic, on the north by its ability to endure low temperatures, and on the west by the margin of the prairie (fig. 78).

Specimens have been examined from the following localities: Lac Aux Sables, Quebec; Auburn, Aroostook County, Androscoggin, Maine; Wellesley, Marthas Vineyard, Woods Hole, No Mans Land, Tuckermuck, Gloucester, Boston, Cohasset, Arlington, Cambridge, Massachusetts; Conanicut Island, Dutch Island, Chepachet Island, Newport, Rhode Island; Falmouth, Bartlett, New Hampshire; Monroe County, Delaware County, Philadelphia, Port Allegheny, Foxburg, Huntingdon County, Pennsylvania; Westport, Adirondack, Catskills, Syracuse, Tioga County, New York city, New York; Sussex County, New Jersey; Washington, District of Columbia; Centerville, Prince

George Island, Branchville, Maryland; Courtland, West Fork, Greenbrier River, North Fork Potomac River, South Fork of Files Creek, Elk River (Cougar's Mills), Beech Mountain, Cheatbridge, Huttonsville, Hinton, West Virginia; Page County, Fairfax County, Arlington, Suffolk, Virginia; Glasgow, Kentucky; Tyree Springs, Union County, Tennessee; Kinston, Raleigh, Jackson, North Carolina; St. Simons Island, Georgia; Enterprise, Georgiana, Kissimmee River, Eustis,

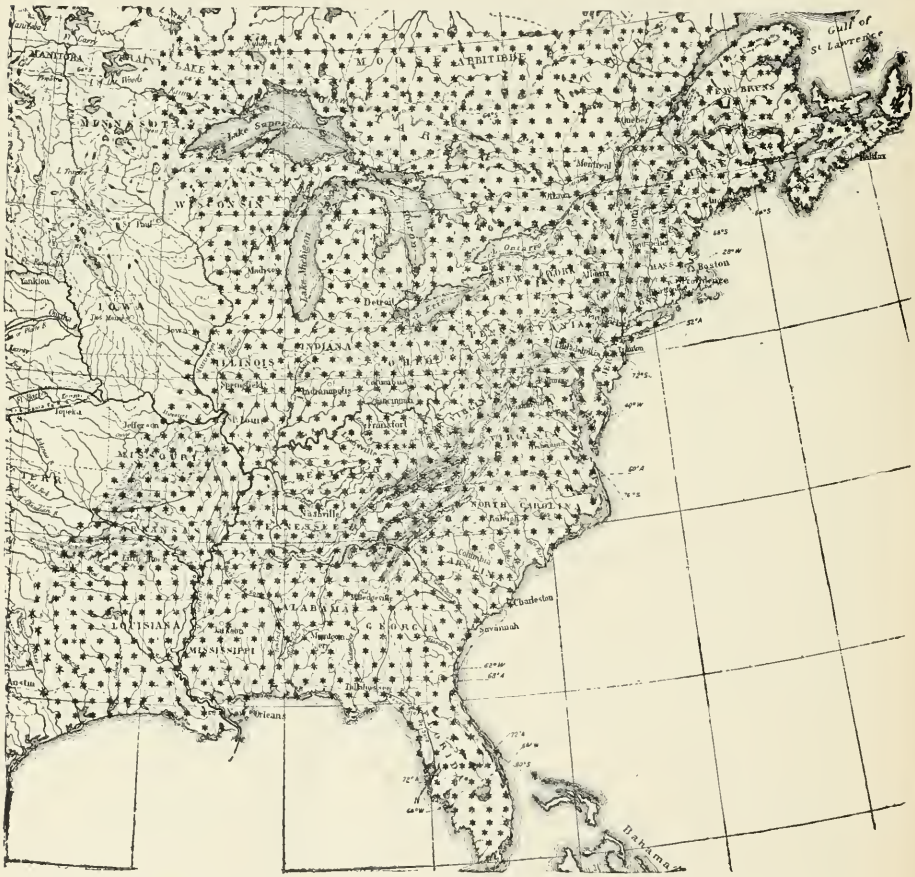

FIG. 78.—DISTRIBUTION OF THAMNOPHIS SIRTALIS, AS INDICATED BY THE LOCALITY RECORDS.

Arlington, Fort Bassenger, Clear Water, Tarpon Springs, Orlando, Florida; Eutaw, Mobile, Alabama; Kemper County, Mississippi; New Orleans, Louisiana; Fort Jessop, Hot Springs, Arkansas; Waco, Texas; St. Charles County, St. Louis, Jefferson County, Crawford County, Oregon County, Missouri; Aux Plains, West Northfield, Mount Carmel, Olney, Chicago, Paris, Rock Island, Lake County, Berwyn, Henderson County, Northfield, Illinois; Lake Maxinkuckee, Vincennes, Bascom, Sims, Indianapolis, Winona Lake, Brookville, Montgomery County,

Indiana; Oberlin, Columbus, Sandusky, Montgomery County, Yellow Creek, Ohio; Washtenaw County, Grand Rapids, Grosse Isle, Livingston County, Eaton County, Oakland County, Oceania County, Crawford County, Iosco County, Alma, Isle Royale, Porcupine Mountains, Bessemer, Houghton County, Baraga County, Marquette, Michigan; Thompson's Lake, Racine, Lauderdale, Milton, Wisconsin; Lucknow, London, Wellington County, Gravenhurst, Ontario, Canada.

It occurs on the nearest of the outlying islands in the Atlantic Ocean and Gulf of Mexico. The most northern reliable records are Isle Royale, Michigan, and Gaspé, Quebec (Cox, 1899), but it doubtless ranges somewhat beyond this latitude. On the other hand, its western limits are neither well known nor definitely ascertainable, for in this direction it intergrades with *parietalis*, the ranges of the two forms being apparently conterminous. At present its western boundary may be considered as closely approximating that of the hard-wood forest. Without doubt typical specimens will be found to occur in Minnesota and Iowa, but this can not now be settled, inasmuch as the principal character (red interspaces between the lateral spots) that distinguishes *parietalis* from *sirtalis* disappears rapidly in preserved material.

Variation.—Notwithstanding the wide range of *sirtalis*, the variation in scutellation is slight. As already stated, the dorsal scale formula is so constantly 19–17 that but two specimens out of some six hundred examined have any other. In these two specimens (one each from Fort Bassenger, No. 22696, and Georgiana, Florida, No. 14833, in the U. S. National Museum) the formula is 19–21–19–17. The labials are comparatively nearly as constant, the average formula for localities throughout the range being very close to 7/10. Occasionally specimens, regardless of their geographic position, exhibit 8 supralabials, and much more rarely 6, while contrary to this the variation in the infralabials 8, 9, or 11 apparently tend somewhat more strongly toward a lower number than 10. This is illustrated in the diagrams (figs. 79–80), which illustrate the conditions in 113 specimens from southeastern Michigan (Livingston, Washtenaw, Oakland, Eaton counties), and the variations in the material examined from every other locality is apparently very similar.

The number of ventral plates varies from 137 to 167, and the average is rather constant throughout the range. I believe, however, that there is a slight reduction in the mean number in specimens from extreme eastern United States. Thus, the diagram (fig. 81) shows that the average for specimens west of the Allegheny Mountains is very close to 154 (between 150–155), but in specimens from Maryland, Massachusetts, and Rhode Island the mean is between 145–149. Based as they are on rather extensive series, I

believe that these averages are quite representative of the actual conditions.

The tail length and number of subcaudal plates also exhibit no noticeable geographic differences. The extremes are: Subcaudals 54–74 (female), 62–84 (male); average for localities with more than fifteen specimens, 64–70; tail length, .192 to .262; average of fifty-four specimens from Washtenaw County, Michigan, .221.

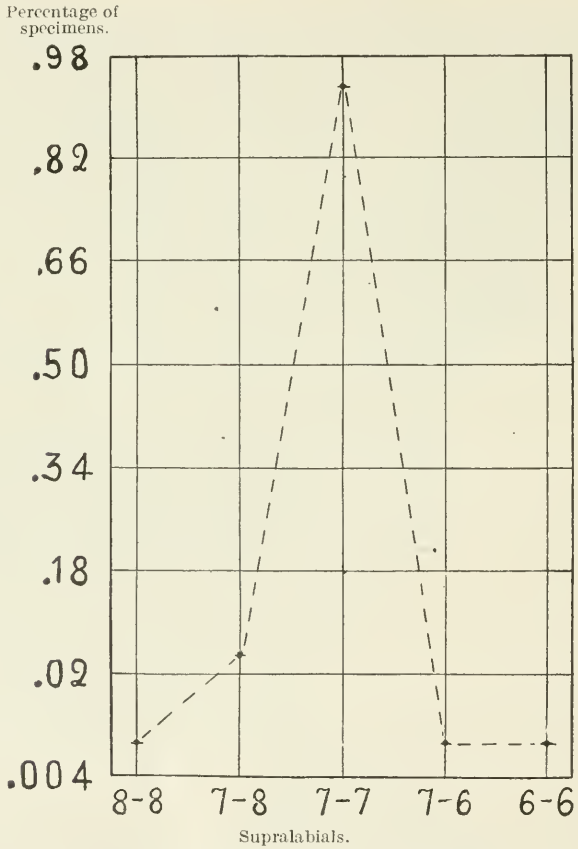

FIG. 79.—VARIATION IN THE NUMBER OF SUPRALABIALS IN 113 SPECIMENS OF THAMNOPHIS SIRTALIS FROM SOUTHEASTERN MICHIGAN.

Similarly but few of the color phases have distinct geographic limits. About six of these forms have been described.

(1) *ordinatus* Linnæus.—This color phase is characterized only by the absence of the dorsal stripe, but even so, if the character were constant, some excuse might be had for considering it distinct from *sirtalis*. As it is, however, the same brood may contain individuals both of this and the normal phase, while among adults various intermediate stages in the distinctness of the dorsal stripe occur, so

that it is frequently impossible to refer a specimen definitely to either form. Nevertheless, while its range is not distinct from that

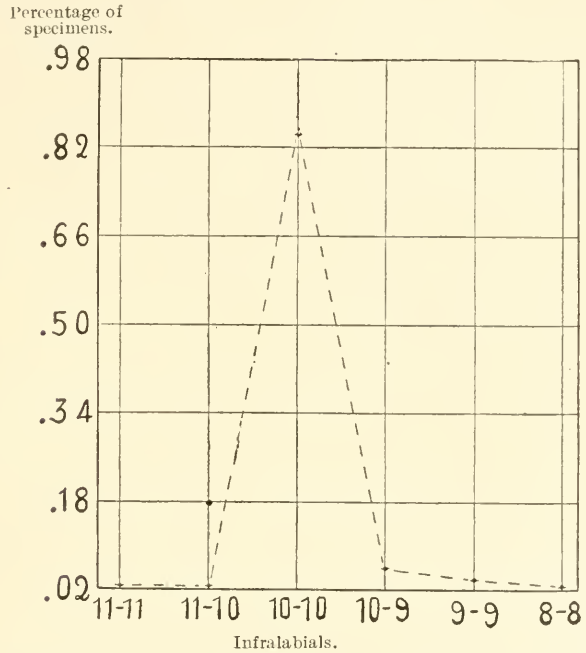

FIG. 80.—VARIATION IN THE NUMBER OF INFRALABIALS IN 113 SPECIMENS OF THAMNOPHIS SIRTALIS FROM SOUTHEASTERN MICHIGAN.

of *sirtalis*, it must be pointed out that the majority of the specimens examined hail from northeastern United States (east of Ohio and

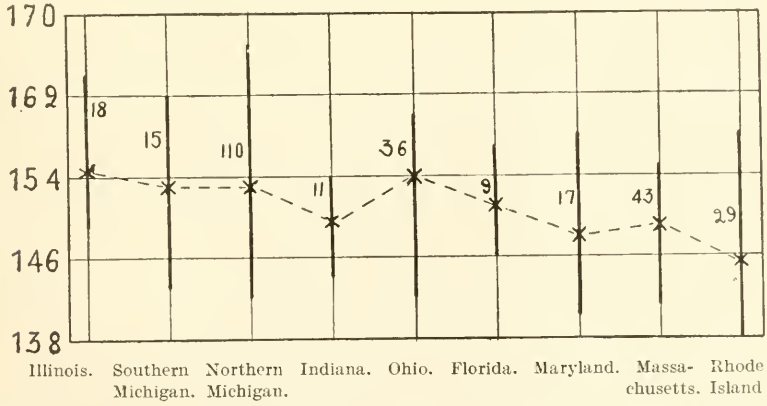

FIG. 81.—DIAGRAM SHOWING THE VARIATION IN THE NUMBER OF VENTRAL SCUTES IN THAMNOPHIS SIRTALIS.

north of North Carolina), those from outside of this region being but scattered records.

(2) *graminea* Cope.—Typical specimens of this phase may be defined as follows: Above light green usually clouded with yellow. Lateral spots not evidenced on scales, except occasionally anteriorly, but present on the skin. Interspaces on the skin bright yellow. Belly light green, often tinged with yellow. Dorsal and lateral stripes absent. This form is very similar to the *ordinatus* phase except that the ground color above is lighter, the dark spots are mostly absent from the scales, and the lateral stripe is not discernable. But, as in *ordinatus*, all intermediates are found between this color phase and that of typical *sirtalis*. In specimens in which the ground color is somewhat darker the dorsal stripe is indicated by a lighter shade on more or less of the three median dorsal rows, the lateral by a similar shade on the second and third rows.

This color phase is very striking, and to one not familiar with the variability of the form it would seem quite desirable to recognize it as a distinct form, the more so as it is apparently common in many localities. From the proportion of specimens in the collections it seems to occur principally in eastern Ohio, becoming rarer in the western part of the State, but extending into eastern Indiana.

(3) *pallidula* Allen.—But little attention has been given to this phase since its original description. It may be described as follows: Ground color above dark. Spots obscured on scales. Stripes dull greenish or bluish, the dorsal more or less obscure. This form differs from *ordinatus* only in the obscurity of the lateral spots and the darkness (often amounting to partial obscurity) of the stripes. It has been recorded from the vicinity of Intervale and Bartlett, New Hampshire, but the University of Michigan Museum expedition secured specimens on Isle Royale, Lake Superior, that are indistinguishable from the topotypes of *pallidula* in the National Museum.

(4) *semifasciata* Cope.—The character upon which this form has been distinguished is very slight and strikingly like the one upon which the form *T. eques collaris* was based. In the specimens referred to *semifasciata* the first two to five spots of the two rows between the lateral and dorsal stripes are opposite and confluent transversely, forming blotches that may or may not cross the lateral stripe. This coloration occurs very frequently in specimens in and immediately about the "prairie peninsula," in Indiana, Illinois, southern Michigan, and southern Wisconsin, and apparently much less commonly to the east and south of this region. But not all of the specimens from this region exhibit this tendency, toward the fusion of the lateral spots into transverse bands anteriorly, in the same degree, Many individuals are found which either have but one or two or even no blotches, and it is evident that the character is far from being a constant one. It is significant that the region where this color phase is best developed is close to the range of *parietalis*, which often exhibits the same phenomenon.

(5) *obscura*.—This so-called variety of various authors has had an interesting history. Defined by Cope as differing from *sirtalis* in the fusion of the lateral spots, it has been made by various writers to embrace slightly anomalous specimens of *sirtalis*, *parietalis*, and *butleri*. The original specimens from Westport, New York, are *sirtalis*, and they are peculiar only in that the ground color above is so dark as to obscure the spots on the scales (by no means an uncommon occurrence). The "*obscura*" specimens of Morse which are not referable to *butleri* are also of this description. Cope (1900, 1074) further describes specimens from Lac Qui Parle, Minnesota, as follows: "The fusion is complete as to the superior row of spots, but the inferior may be seen faintly outlined on stretching the skin, as in some dark forms of *E. s. parietalis*." This would seem to denote that the spots on the other specimens referred to *obscura* by Cope (those from Westport, New York) were entirely fused on the skin; but this is not true, for on stretching the skin of the latter the spots are seen to be perfectly distinct. As a matter of fact the Minnesota specimens referred to *obscura* by Cope are *parietalis* (in which the upper row of spots is normally fused), the New York specimens of this writer and the Ohio specimens (in part) of Morse being rather dark specimens of *sirtalis*.

I have already alluded to the fact (see p. 88) that both Morse and Cope have referred specimens of *butleri* to *obscura*. This was made possible by the insufficiency of the original description of the latter, which gives the impression that the spots are fused on the skin in typical specimens, which is the case to a considerable extent in *butleri*.

(6) In many specimens from Indiana, Ohio, southern Michigan, and western Pennsylvania the skin between the first and third or fourth scale rows is more or less red. On the basis of such specimens it has been asserted that *parietalis* occurs in the above named States. These specimens are typical *sirtalis* in every other character, while the red when present is always in such a small amount that the specimens need never be confused with *parietalis*.

While in my judgment it is impossible to recognize any of the above forms as distinct, I believe that the first three (*ordinatus*, *graminea*, and *pallidula*) are significant in that they represent the same tendency in the form, i. e., toward an increased darkness in color. I believe that the increasing darkness of the stripes (which leads to their obscurity) is an evidence of such a tendency. This explains the fact that the extremes in this direction (those in which the stripes are obscured and which have been described as distinct) have no distinct geographic range, but are liable to crop up in any considerable collection of specimens from almost any locality in the range of the form. Nevertheless it seems to be evident also that the tendency is much more pronounced in the north and northeastern than in south and southeastern parts of the range, although a considerably larger

number of specimens is needed from the latter region before this point can be definitely demonstrated.

Affinities.—The only apparent near relative of *sirtalis* is *parietalis*. I have already discussed this relationship. It should be pointed out, however, that the fact that typical specimens of *sirtalis*, from Indiana to western Pennsylvania, have frequently a small amount of red pigment on the sides, also points toward a relationship between these two forms. Brown's (1904, 470–471) ingenious suggestion that *sirtalis* is related to *radix* through *butleri* has little to recommend it, for from my point of view there is no evidence from the scutellation that *sirtalis* is at all nearly related to *butleri*, although the general similarity in the scutellation and the intermediate position of the lateral stripe in the latter has been occasionally seized upon as indicative of such an affinity, while there is no evidence either in the position of the lateral stripe, scutellation, or geographic distribution that it is anything but distantly related to *radix*. To establish a relationship with the forms of the *Radix* group one must entirely ignore the evi-

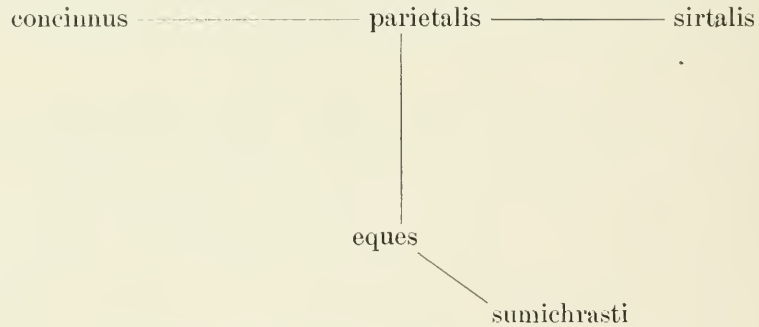

FIG. 82.—PHYLOGENETIC DEVELOPMENT OF THE SIRTALIS GROUP.

dence of the lateral stripe and the geographic probabilities, as *sirtalis* entirely overlaps the range of *butleri*, and in part the range of *radix*, without showing the slightest modification in any character that would point toward any close relationship with either form.

CONCLUSION.

Of the four groups into which I believe the genus *Thamnophis* is differentiated, the *Sirtalis* group is without doubt the least diversified. This is shown by the fact that most herpetologists have been willing to give to its members but subspecific rank, owing to their evident intergrading, and by the further fact that variation, geographic or otherwise, is very slight. If we grant the unity of the group as here described (fig. 82) the geographic differences may be outlined as follows:

1. The dorsal scale rows are 19–17 in most forms, the only departure from this formula being in southern Mexico, where it becomes 17–15.

2. The supralabials are normally 8 in the two forms in Mexico and 7 in the others. The infralabials are normally about 10 in all forms.

3. The ventrals, subcaudals, and tail length are, so far as known at present, practically the same throughout the entire range of the group.

Thus the geographic variations in the scutellation consist of a maximum of 19–17 dorsals and 8 supralabials in the form whose principal distribution is on the Mexican plateau (*eques*), and of a reduction in the dorsal scale formula in the forms to the southward and in the number of supralabials in those to the northward of the range of this form. It only remains to be pointed out that the area of principal reduction between the forms with a different scutellation is small.

DISCUSSION OF ORIGINS.

In the general discussion of the characters and variation in the genus, as well as in the detailed discussion of the various forms, I hold to have established two fundamental facts as follows: (1) That the genus *Thamnophis* is naturally divided into four groups of nearly equal importance, the component forms of which are directly related; (2) that each of these groups is represented by a form in the northern part of Mexico and in southwestern United States which has the maximum scutellation for the group. To what extent do these facts throw light upon the question of origins? Darwin pointed out in his Origin of Species that on the principle of descent with modification the only rational view is that the several species of a genus have been derived from a common progenitor and have undergone modification in the course of dispersal. We are then confronted with the problem of locating the center of origin of a genus before we can intelligently search for laws governing the modifications which have resulted in the component forms as we find them at the time of our study.

Various criteria have been formulated toward this end.[a] At least one of these can not be used in this instance, as it is based on peculiar conditions existing in one group of animals: it is the direction of the annual migration routes of birds (Palmén). Of the others I believe that Adams's sixth criterion is of the most general and easy application as well as logically (assuming, of course, the theory of descent and single centers of origin) the most reliable. This rule is that the different lines of dispersal in any genus radiate from, or, conversely, converge toward, the geographical center of origin. As already mentioned, I believe that this rule follows logically from the theory of descent formulated by Darwin, so that if only the lines of dispersal can be determined in any group in which there are more than one, it should be relatively easy to fix upon the center of origin of that genus. In discovering that different nearly equal groups of related

[a] See Adams (1902 *b*).

species occur in the garter-snakes, I have proof that different lines of dispersal have been followed; and it will furthermore be recalled that, as I have defined these groups, they are each composed of forms which are distributed linearly. When I find, then, that nowhere else in the range are all of the groups represented, I am justified in concluding that the genus has had its origin in a general way in northern Mexico.

As a corollary to this criterion is Adams's first test, namely, that the center of origin is the location of the greatest differentiation of a type. If the lines of dispersal converge toward or radiate from the center, in this general region and here only, it should be possible to find representatives of each group or lines of directly related forms. This is exactly what occurs in the genus *Thamnophis*. In no region except Mexico can there be found representatives of all of the four groups of garter-snakes, while at least to the northward representatives of but one or two groups are found toward the outlying parts of the range.

The application of either of the above tests, however, can not, in my opinion, be trusted to indicate more than the general region in which the center of origin of the garter-snakes is located, for in a constricted area like Mexico and Central America the groups differentiated in one part must of necessity remain together *geographically* until they emerge into a more extensive land area, such as North and South America. This is exactly what occurs, for the four groups occur throughout Mexico, although, as will be shown later, they probably became differentiated in a particular part of this general region.

Another test that has been suggested is the one laid down by Allen that synthetic forms will be found at the center of origin. It is one that naturally follows an acceptance of the theory of single centers of origin, and is closely bound up with the first two criteria cited—the convergence of lines of dispersal and the location of the greatest differentiation of a type. At the center of origin of the genus of garter-snakes, then, theoretically all four groups should be represented, and the representatives of these groups should be more closely related than any other representatives of the groups. This point is difficult to test, owing to the fact that the different groups as they diverge genetically and often geographically may converge in appearance. This reduplication of forms in widely separated areas occurs to such an extent in the garter-snakes as to make it often difficult or even impossible to determine specimens without a knowledge of the locality in which they were taken. This parallelism is brought about by the reduction in size which takes place as the groups depart from the center, as this reduction in size is accompanied by a reduction in scutellation. Thus every group has forms which are practically identical in the number of scales in each series.

This is best shown in the *end forms*. Thus in *butleri* (Indiana, Ohio, etc.), *ordinoides* (coast of Washington, Oregon, and northern California), *scalaris* (Veracruz), and *sumichrasti* (Veracruz) the scutellation is often identical, while the coloration in but one of these, *scalaris*, can be relied upon as a differential character. As stated above, the similarity of such forms often makes it difficult to distinguish between parallel and synthetic types, but an exact knowledge of the value of differential characters and of geographic distribution and trends of variation will allow the distinction to be made. While it is thus impossible to accept similarity in scutellation between the forms of different groups as always indicative of nearness of relationship, it is significant that where the groups come together geographically their representatives also come to resemble each other closely in scutellation. Thus, in *megalops*, *angustirostris*, *eques*, and *proximus* the labials are practically the same in number, and the number of ventral scutes is as nearly the same as can be expected for so variable a series. It is true that the usual dorsal scale formula in *megalops* and *angustirostris* is 21–19–17, while for *proximus* and *eques* it is 19–17, but it must be remembered that it is nowhere higher than 19–17 in the respective groups to which *eques* and *proximus* belong, so that these forms resemble *megalops* and *angustirostris* more closely than the two latter are resembled by any other forms of the *Sauritus* and *Sirtalis* groups. While, therefore, similarity in scutellation does not necessarily in itself (especially at the limits of the range of the groups) imply close relationship, if we grant the evidence of the other criteria that the center of dispersal is in Mexico, there is no objection from this standpoint, for *angustirostris*, *megalops*, *eques*, and *proximus* give every indication of being more closely related to each other than any other four forms in the different groups. If this is true it restricts the center of origin of the genus to northern Mexico.

Two other criteria of Adams may be considered together, i. e., "continuity and direction of individual variation or modification radiating from the center of origin along the highways of dispersal" and "direction indicated by biogeographical affinities." Evidently, it seems to us, both of these criteria are of importance in any investigation of this kind, for, while they are not concerned primarily with the conditions at the center, they are supreme tests of the genuineness of the lines of dispersal, which must be determined before the center can be located. The tests can be reformulated as follows: Are the variations in the forms along any supposed lines of dispersal continuous, and is it probable geographically that the forms are related in the supposed manner? For instance, I might divide the garter-snake into several groups on the basis of similarity in the number of scale rows, but if I then applied these tests we would find that

not only would the forms of each group fail to intergrade with each other in their variations, but that it would be extremely improbable, in view of their geographic location, that they were at all closely related. As it is, *each group is formed of a line of directly related forms, the extremes of which are very distinct, but those which are geographically nearest together are but slightly different from each other.*

As previously stated, I believe the tests used above are valid, and when applied show the utter untenableness of the hypothesis put forward by Cope and Brown that the center of dispersal is in southeastern United States and that *sirtalis* is the ancestral form. From the latter standpoint the groups which we have distinguished in the genus must be ignored and the forms connected in a manner entirely antagonistic to the criterion that the lines of dispersal shall be indicated by continuity in variation and be in harmony with geographic probabilities. Note in the diagram of affinities given by Brown (1904, 471) that the lines of genetically related forms fullfil the requirements of neither of the above tests, and that, admitting the validity of our own groups, we can get, at most, but three lines radiating from eastern North America, and one of these does not reach the southeastern States! If the criteria discussed above are valid I believe that they indicate unquestionably that the center of origin is in northern Mexico, and I may test the other criteria that have been formulated by different writers.

Two other criteria of Adams may be considered together. They are: That the center of origin will be marked by a "dominance or great abundance of individuals" and by a minimum "dependence upon a restricted habitat." Neither of these postulates is true in this genus, for, although much yet remains to be discovered on the habitat relations and abundance of the different forms, garter-snakes are not noticeably abundant but rather rare in the desert and coastal regions of northern Mexico and southern New Mexico and Arizona, while in many places in North America they are almost incredibly numerous.[a] Again, on the plateau of Mexico and in southern New Mexico and Arizona, which forms the home of three of the groups, the conditions are very arid, and these snakes are evidently confined principally to the immediate vicinity of mountain streams and similar environments where water is most abundant. On the other hand, in the forested regions of North America, notably in eastern United States, the forms, although showing habitat preferences, are of quite general distribution. This is exactly what one might expect in view of the preference shown by these snakes for a moist habitat. It has been objected that this habitat preference argues against the conclusion that the genus originated in northern Mexico. I can not see the force of this argument, for it seems to me that partially aquatic

[a] See Van Denburgh (1897, 212) and Ruthven, p. 73, in this paper

forms may originate in favorable environments in arid regions, just as strictly aquatic forms may do so. I believe, therefore, that, in cases of this kind at least, these two criteria (abundance and least restriction to a particular habitat) are not valid, for a group may originate in a region where the environmental conditions to which it is adapted are more restricted than elsewhere.

The fifth criterion of Adams, "Location of greatest productiveness and its greatest stability" (Hyde, 1898, p. 575), is in the main inapplicable in this study, owing to our almost total ignorance of the breeding habits of the various forms. It seems worth recording, however, that the most dwarfed forms (those with the smallest scutellation) have apparently a fewer number of young in a brood than do the larger forms, as might be expected. For example, *butleri* generally has about a dozen young in a brood, while *radix* may have forty or fifty. As the relative productiveness thus seems to be correlated with size in this genus, the location of the area of greatest productiveness would be near the center of origin, but even if this should be found to be the case it would prove only that the test can be used in genera in which the forms are the result of dwarfing. However, as said above, so little is known of the breeding habits of these snakes, that it is hazardous to attempt any general conclusions at this time.

Another criterion that is quite easy to apply is the one formulated by Allen in 1877 (1877, 378): "The representatives of a given species increase in size toward its hypothetical center of distribution, which is in most cases doubtless also its original center of dispersal." In snakes it is doubtful if we have any such a thing as "adult size" in the sense employed in birds and mammals, so that, without some method of indicating dwarfing, this criterion is valueless. Fortunately we believe that differences in the number of scales in the dorsal, labial, and ventral series is, as outlined in the chapter on variation, an index to the relative size in these snakes, and, if so, we have in these characters a ready means of determining the relative dwarfing of the different forms, even if young specimens alone are available for study.

Applying this criterion to the conditions outlined in the description of the different forms the results are startling, for *in every group the maximum scutellation is found in the form which inhabits northern Mexico, while from this region the scutellation decreases progressively in the different forms, so that the minimum is only found in the forms which constitute the extreme ends of the series, and are thus genetically and geographically most distant from the form with the maximum number (at the center).* In other words, *the forms of the same group are progressively more dwarfed away from northern Mexico.* [This does not include those forms of the *Sirtalis* group (*concinnus* and *sirtalis*), which are

based only on color characters.] The results are exactly those which we should expect if the criterion is a valid one, and the center of origin is in the northern Mexico, as indicated by the convergence of the lines of dispersal, but it must be recognized that while these facts may be in harmony with the theory, they can not be considered as proving it until the cause of dwarfing is known.

METHOD OF EVOLUTION OF THE FORMS.

It is not the purpose of this paper to discuss the causes of evolution in the garter-snakes, for the study of distribution and variation alone can not encroach upon the field of experimental morphology in determining the causes and effects of the processes which effect the animal form. It is the province of such studies, however, not only to point out probable origins and relationships, but also to search for the methods of evolution, so that the experimentor may work intelligently in his search for the processes which cause the production of one species from another.

If the range of the forms in the different groups of garter-snakes be carefully examined it will be found (1) that the different forms of the same group are found in different geographical regions, characterized by different environmental conditions; (2) that the area along the common boundary of two forms of the same group, where transition in characters takes place, is relative narrow.

These conditions are exactly in harmony with Stone's (1903, 659) statement for terrestrial vertebrates that "we never find two geographic races or subspecies of the same form occurring together, except during times of migration," and Jordan's (1905, 547) statement that "given any species in any region, the nearest related species is not likely to be found in the same region nor in a remote region, but in a neighboring district separated from the first by a barrier of some sort." Steere (1894, 419) evidently had the the same point in mind when he formulated the law "the genus is represented by only a single species in one place," but he expressed it too generally, for as a matter of fact, as shown in this genus, two or more species may occur together in the same environment, but the *direct relative* of any species is to be found not in the same but in a neighboring environment. In the light of the results of this investigation, as well as the known instances in which different species occur in the same geographic area but in different environments, it seems expedient to reformulate the law to read as follows: *Directly related forms on any line of descent generally occupy neighboring environments.* Although expressed in different terms, this is exactly the same conclusion arrived at by Ortmann (1906, 512) in his study of the crawfishes of Pennsylvania.

At the present time it seems to be becoming recognized that the above law is of wide application among the higher orders of verte-

brates. However, any attempt to determine from geographic and variation data that internal factors, the direct influence of environmental conditions, or in fact any other cause is responsible for this close correlation of particular forms with particular environments must fail to be conclusive, for experimental work alone can definitely reveal the influence of the environment upon the dwarfing and scutellation in these snakes. In the case of the garter-snakes, however, it should be noted:

1. That most of the forms are the result of dwarfing.

2. That the amount of dwarfing does not seem to be directly associated with the nature of the environment, for the form inhabiting a particular region is only slightly different from its nearest neighbor in the same group, while forms of widely different scutellation may inhabit the same region. Thus the conditions which apparently determine the scutellation of any form is the scutellation of its immediate progenitor, and the dwarfing which it has itself undergone.

While therefore—although it is without the province of the present work to seek to determine just what factors in the environment make it unfavorable for these snakes—I believe that I am justified in concluding that the dwarfing is associated in some way with the environment; it is as if the different environmental complexes encountered by the groups as they radiated from the center of dispersal were generally unfavorable, and the most tenable hypothesis is that the changed conditions of environment acted as a stimulus (unfavorable to growth) upon these snakes (Tower, 1906, 294–296). If this is true, isolation while attending the production of the forms in each group has had no other apparent effect than that of keeping them distinct as they were formed.

Allen (1876, 310) concludes from such evidence that the environmental conditions at the center are the most favorable for the existence of any group, and Adams (1904, 210) that the center of dispersal corresponds to a center of optimum vital conditions. It follows from Adams' standpoint that as a form enters other regions in which there are any changes in the optimum conditions these changes may be considered as unfavorable, whether they are in the way of an increase or decrease, since the zero point of a stimulus corresponds to the vital optimum and is situated between the minimum and maximum, both of which result in death. However this may be, the following facts will stand: (1) That the maximum scutellation and size in the genus *Thamnophis* occurs at the center of dispersal, and the forms that have been produced in the history of its migration have been formed principally by dwarfing and by a reduction in scutellation; (2) that the variation in the number of scales in the different series is definite and not promiscuous, and is correlated in a remarkable degree with changes in the environment.

The development of the different groups has thus been orthogenetic. This is nowhere better shown than in such forms as *radix*, where, as one passes from the western to the eastern parts of the range, not only the average but also the maximum and minimum numbers of plates in the different series decrease steadily, until the range of *butleri* is reached; and that this is in some way associated with the environment is shown in the numerous instances in which the transition from the scutellation of one form to that of another takes place rapidly, and along the boundary of different sets of environmental conditions. Even in the latter instances the variations are evidently orthogenetic, as shown by the fact that geographically there are marked differences in the maximum, minimum, and average number of scales in the different series. I have failed to find the slightest evidence that forms have been produced by mutations in this genus.

From these facts, then, it seems to me that the most tenable hypothesis of the evolution of the genus *Thamnophis* is that it originated and became differentiated into four main groups in northern Mexico. From this region the groups radiated in all directions, but principally to the northward, and wherever they entered different regions the changed environmental conditions acted as an unfavorable stimulus, which retarded growth, and differentiated the groups into dwarfed forms. If this explanation is the true one, the influence of the environment without doubt affects the young snake before birth, since the scutellation, at least as regards the number of scales in the dorsal, labial, ventral, and subcaudal series, is determined before the young are born.

THE GARTER-SNAKES AS MATERIAL FOR EXPERIMENTAL INVESTIGATION.

So far as I know, snakes have rarely been used for experimental purposes. They are unfitted for this both by the fact that apparently but one brood is raised each year and that they are difficult to keep in captivity. The garter-snakes, however, are free from both of these objections, since they are hardy in captivity, and while raising but one brood a year are very prolific. For these reasons they should present very good material for the investigator, the more so as they may be had in numbers almost anywhere in the United States. It should be borne in mind, however, that when in captivity they must be kept, as nearly as possible, in natural conditions.

Undoubtedly the problems that should first be attacked are the inheritability of the scale characters and the influence of different factors (inbreeding, unfavorable conditions of food and temperature) in producing dwarfing. The latter problem may be attacked in two ways: An attempt may be made to cause an increase in size and scutellation in dwarfed forms, such as *butleri* and *ordinoides*, or to

produce dwarfing in the larger forms, such as *radix*, *elegans*, and *megalops*. In selecting material for such work, however, the apparently more variable forms of the *Radix* and *Elegans* groups should be chosen in preference to the less variable ones of the *Sirtalis* or *Sauritus* groups. Properly handled, these snakes should furnish the best material not only for the investigation of the problems peculiar to the order, but also for the study of general problems of heredity and evolution.

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